The Dock and Harbour Authority

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Editorial Comments

Southampton: Premier Passenger Port.

Southampton figures so conspicuously in the pages of English history and in the annals of British commerce, that it is obviously impossible to do justice to its claims on the attention of our readers within the restricted limits of an editorial comment. We must content ourselves with a commendatory reference to the Paper which was read by Mr. R. P. Biddle, the Docks and Marine Manager of the Southern Railway, at the recent Congress of the Institute of Transport. Through the courtesy of Mr. Biddle and of the Institute, it forms the subject of our leading article and illustrated supplement in this issue. The combination of material affords a concise, but comprehensive, survey of the port's development and of its present activities, from which a serviceable impression may be gained of the manifold directions in which the port plays so important a part.

Notable as are its commercial and trading operations, the reputation of Southampton has chiefly been enhanced by its enormous passenger traffic, in which respect Mr. Biddle justifiably claims for it a foremost position in the world. Whether to the United States or Canada, to South Africa, South America, Australia or New Zealand, or on the shorter excursions of the popular summer cruises organised by numerous shipping companies, Southampton is the chief port for arrival and departure. Travellers frequent it from all parts of the globe, and approximating to three quarters of a million passengers cross its quays during a year.

Much has been done to foster and develop this traffic by the Southern Railway Company, who hold in point of fact, the position of port authority in so far as the docks and their appurtenances are concerned, and a tribute of compliment is due to them for their initiative and enterprise in providing not only the essential accommodation and conveniences for the service of passengers, but also the pleasant amenities of green turf and gay parterres which grace the road approaches to the quays, thereby brightening the environment and creating a favourable impression on visitors from abroad.

The subject of maritime passenger stations has previously been dealt with in this Journal, and we have strongly urged the raising of the standard of accommodation to that obtaining in Continental ports of the first rank. It is satisfactory to record that an appreciable advance has been made of late years, but it has to be pointed out there are still respects in which a little more consideration might be displayed for the physical comfort of passengers during the trying ordeal of the Customs' examination on returning from abroad. The problem is not altogether an easy one to solve, and it will require the co-operation of all the official administrations concerned, but there is undoubtedly room for improvement, which, we trust, will not long be delayed.

Spanish Harbour Reconstruction.

As an aftermath of the internecine struggle for mastery between the rival parties in Spain, the new Spanish (Franco) Government is under the necessity of reinstating, or rebuilding, a number of the country's ports, which were damaged and, in fact, more or less completely destroyed during the period of hostilities. In the south and east of Spain, particularly, the harbours of Cartegena, Alicante, Valencia, Castellon de la Plana and Barcelona, suffered very severely, and there are still some thirty sunken ships obstructing the area of the last-named harbour.

Advantage is to be taken of the Government's recent legislation for the extension of the Spanish Mercantile Marine to improve and extend the accommodation at a number of the ports affected. An important section of the work will be centred in the province of Guipuzcoa, one of the Basque provinces, in the south-east corner of the Bay of Biscay. The harbours of Fuenterabia, San Sebastian, Deva, Orio and Notrico are to be enlarged, and provision is to be made for carrying out dredging work at Guetaria and Notrico, and for the construction of jetties at Zumaya, Notrico, San Sebastian, and Guetaria. At Pasajes, near Irun, on the French frontier, new Administration and Customs offices are to be built, as also additional quayage and railway sheds.

The coastal signalling system, moreover, is to be remodelled. Lighthouses at Cape Hijuer, Guetaria, Fuenterabia, Pasajes and elsewhere, will be reconstructed, or repaired, with the installation in some cases of electric sirens. The harbour of Senecozulua is to be equipped with a radio lighthouse operating electro-acoustic signals.

Although the opportunity and the decision to make these improvements is to be welcomed, the senseless devastation in the first instance of so much that has hitherto been serviceable in the prosecution of overseas commerce, is greatly to be deplored. Spain has a great amount of leeway to make up before she can gain her former position in maritime affairs.

The 25th Anniversary of the Panama Canal.

A quarter of a century has now elapsed since the outbreak of what we have been in the habit of calling " the Great War." Its " greatness " was manifested in carnage and devastation, in human grief and human suffering, which alas! have not brought home to some nations of the world the folly and stupidity of armed conflict. Much more pleasing it is to recall that, at the same distance of time, was inaugurated one of man's most outstanding achievements, rendering real service to civilisation and marking an epoch in the advance of navigation.

On August 15th, 1914, within a fortnight of the outburst of the European conflagration, the little steamship, "Ancon," belonging to the Panama Railroad Company, passed through the completed Panama Canal and established the connection of the Atlantic and the Pacific across the narrow isthmus. Since that date, up to the present year, more than 100,000 ships, individually exceeding 300 tons burthen, and some 500,000,000 tons of goods, have passed through the waterway, which saves nearly eight thousand miles in the voyage from San Francisco to New York, as compared with the former route via Cape Horn, and affords corresponding economies of time and travel between other ports in the two hemispheres.

To the thoughtful observer, how fundamental has been the transformation in the narrow strip of land which links the North and South American Continents, and how astounding the development of its virgin territory, since the seemingly far-off days of the early pioneer adventurers and of

> " Stout Cortez, when, with eagle eyes,
> He stared at the Pacific—and all his men
> Gazed at each other with a wild surmise—
> Silent, upon a peak in Darien."

The cost of the Panama Canal with its later improvements, has been something over a hundred millions sterling, but its beneficial results have fully justified this expenditure. The cost

Editorial Comments—continued

of the "Great War" has been estimated at more than 50 thousand millions in actual expenditure, while it is incalculable as regards loss of life and property, and it has left a legacy of bitter hatred and an insatiable lust for conquest by Dictatorial Powers.

The Seine Estuary Crossing.

Allusion has been made in these columns some months back (November, 1938) to the agitation for improved means of communication and land transport across the Estuary of the Seine. At present, the connections nearest the mouth are the road and rail bridges at Rouen, both distant some 80 miles inland from the Port of Havre, which has to rely on ferry boat services for contact with Honfleur, Trouville and other ports and seaside resorts on the opposite bank of the Seine. It will be remembered that two projects have been put forward: one for a high-level road bridge and the other for a tunnel, and each of these has been advocated strenuously by one or other of two conflicting interests. The people of Havre preferred the bridge as a much less expensive proposition, while the inhabitants of Rouen, entertaining fears that the river channel and access to their port might be blocked in case of the collapse of the structure under aerial bombing attack, favoured the tunnel scheme.

The bridge proposal has now materialised to the extent that plans have been prepared and submitted to the French Government, who have approved them, subject to a public inquiry on the question of the general utility of a bridge. The Inquiry was opened in the closing days of July and closed on August 5th, subsequent to which the evidence tendered has been under the consideration of a special Committee, comprising the Presidents of the Chambers of Commerce of Rouen, Havre and Fécamp, and a representative of the shipbuilding interest, with Monsieur Leon Meyer as Chairman.

Up to the time of going to press, no information has been received as to the decision of the Committee. Indeed, as the matter is of serious moment to two rival ports of the greatest importance in France, it is bound to receive the most careful consideration before a definite commitment is made.

The Navigable Channel of the Nene.

Although the functions of the various Catchment Boards in England and Wales, created under the Land Drainage Act, 1930, are mainly concerned with the prevention of floods and the conservation of water supplies, yet in the treatment of rivers for this essential purpose, there are involved rectification works which may also serve for the benefit of navigation. Indeed, in certain cases, it is difficult to distinguish between the functions of the Catchment Board and those of a Navigation Authority, and sometimes the two are combined.

Such an arrangement obtains on the River Nene, which, flowing into the Wash, is the navigable approach channel for the ports of Wisbech and Peterborough, and the far inland town of Northampton. The Nene has, hitherto, been naturally tidal as far as Peterborough, but the installation of the "Dog in a Doublet" Sluice, described in the issue of this Journal for October, 1937, and other works, have served to stabilise the depth of water to a minimum of 10-ft. Sea-going vessels now make regular journeys to Peterborough, which is 40 miles from the sea, and cargoes of French wheat are discharged there.

The Port of Wisbech, also, has profited very greatly from the operations of the Catchment Board. The import trade has considerably more than trebled itself during the last six years, having risen from 17,000 tons in 1933, to 51,000 tons during the first six months of the current year.

There was an official inspection of the river towards the end of July, attended by Sir Donald Ferguson, Permanent Secretary to the Ministry of Agriculture, several Members of Parliament and Mayors and heads of Municipal Authorities in the Midlands. The nature and extent of the improvements in the vicinity of Wisbech are described in this issue.

The "Mauretania" and her Home Port.

The entry on the evening tide of August 6th of the new ss. "Mauretania" of 35,739 tons gross, into the King George V. Dock at North Woolwich, was an event of some significance in the history of the Thames and the Port Authority. Hitherto, the largest vessel using the Port of London has been the Cunard-White Star liner "Georgic" of 27,759 gross tons and the increase of 8,000 tons in gross tonnage of a single vessel is a very marked advance in the demonstrated capacity of the port accommodation.

The manœuvring of exceptionally large ships in narrow waterways is necessarily attended with some amount of risk, and it is highly creditable to the Authority's foresight that the Thames channel has received such systematic treatment as to be safely negotiable by the "Mauretania." Indeed, it may be said with confidence that an appreciably larger vessel could have been navigated from the Nore to Gallions. After leaving her anchorage at Tilbury, no tugs were employed by the "Mauretania" in rounding the bends in the river and the 14 miles of route were traversed under her own helm and with her own motive power.

As regards the dock entrance, when the King George V. Dock was planned some 25 years ago, although such an eventuality was hardly likely to occur for a long time, the lock was designed for the reception of vessels even larger than the "Mauretania" and it can undoubtedly accommodate them in length and draught. Greater beam might, however, prove a difficulty, for though the width of the lock actually left a margin of 5-ft. on each side of the hull of the vessel, yet the slight overhang of the upper portion of the bascule bridge brought the navigating bridge nearly within touching distance. This possibility of contact at high levels is not a negligible consideration in the passage of modern ships through dock entrances.

Happily, in the case of the "Mauretania," everything went according to programme and the successful achievement of the docking operation is a matter for congratulation to the Authority, their river and dock officials and the docking pilots.

Refuse Transport on the Thames.

A definite step forward in the interests of public health and sanitation has been taken by the City of London Corporation, acting as the Health Authority for the Port of London, in submitting to the Ministry of Health new bye-laws which will have the effect of preventing nuisances arising from the transport of refuse down the Thames. Under the proposed bye-laws, the barges used in this work must be fitted with close-fitting hatchway covers, completely enclosing the refuse, and protected with waterproof sheeting. The hatches are to be kept covered at all times, except during periods of actual loading or discharging, and refuse must not be loaded above the coamings. After discharging refuse, all barges must be cleansed before any other cargo is loaded, or within six hours of discharging refuse.

Anyone who has witnessed and smelled the repellent, odiferous material deposited on the lower banks of the Thames for use as filling, will appreciate this welcome control of a traffic which, although it is inevitable, is a source of danger to health. At the same time, it has to be admitted that the men engaged in the work, like sewermen, are not conspicuous sufferers from disease engendered by their occupation. Possibly, they become immune or case-hardened. But the public are not so insensitive to material which is a favourite haunt of flies and a harbourage for rats.

The new bye-laws have already become operative, but they will not be strictly enforced for a couple of years, in order to allow the firms engaged in refuse transport, time to effect the necessary structural changes in the barges. A number of craft are already fitted so as to comply with the new regulations.

Proposed Developments at Alexandria.

The important announcement has been made in the Egyptian Chamber of Deputies by the Minister of Communications that it is the intention of the Egyptian Government to spend a sum of three millions sterling on the improvement and development of Alexandria Harbour. The Great Pass, the main shipping entrance, is to be deepened to a depth of 42-ft., as compared with the present depth of 35-ft., and a new petroleum basin is to be formed in the inner harbour. Included in the programme are a new graving dock, the dimensions of which are not yet announced, and some additional quayage with an extension of the breakwater.

The Bay of Alexandria lies in a exposed position in the South-East corner of the Mediterranean and has a length of about 7 miles between the extreme headlands of Ras-el-Tin and Agami. Across this intervening space lies a large rocky bank, more or less parallel to the coast, through which there are two navigable passes: the Great Pass, 600-ft. wide and the Boghaz Pass, 300-ft. wide; both about a mile in length. When seas are at all heavy, the Boghaz Pass is impracticable for deep-draughted shipping and the Great Pass is the more reliable approach to the port. The additional depth should materially increase its serviceability.

The Southampton Floating Dock.

An incorrect statement in a leading London Daily—usually reliable as regards its information—led to our making an editorial comment in the last issue on the supposed transfer of the Southampton Floating Dock to Alexandria. We have since learned that no such transfer has taken place, and that the floating dock in question is still located at Southampton. We greatly regret the mistake, which we take the earliest opportunity of correcting. The dock now at Alexandria was formerly at one of H.M. Dockyards, and is of considerably less calibre than the Southampton Dock.

Institution of Civil Engineers: Vernon-Harcourt Lecture.

We are informed that the Vernon-Harcourt Lecture for the 1939-40 Session of the Institution of Civil Engineers will be delivered in London, on December 6th, by Mr. A. C. Gardner, M.Inst.C.E., Chief Engineer to the Clyde Navigation Trust, who has selected for his subject: "The Construction of Deep-water Quays."

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A Great Passenger and Trading Port

By R. P. BIDDLE, M.Inst.T.,
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Introduction

THE subject of this paper is probably a little unusual in the sense that it deals with the actual history and amenities of a Port rather than with academic principles in relation to port working in general, and in these circumstances, therefore, it may to some extent lack the controversial element which has sometimes been a feature of papers read before the Institute of Transport.

I propose to deal with the subject under the following headings:—

Historical Survey; Natural Endowments; General Development; Industrial Development; Shipping; Rates, Dues and Charges; Cargo Traffic; Passenger Traffic; Conclusion.

History

The history of the Port of Southampton stretches far back into centuries B.C., and in the early days of the Christian era there are records of the steady development in maritime trade. By the time of Edward the Confessor the town and port had reached a state of considerable importance and wealth.

In the year **1150**, the wine trade commenced; this played an exceedingly important part in the prosperity of the town and the history of the port, and many of the numerous vaults which honeycombed the High Street and Quay districts are still in existence.

The prosperous state of the port, which had been enhanced by the extension of the Venetian trade and commerce with the East from **1325** onwards, was interrupted in **1338** by the rupture with France over Edward III's claim to its throne. The Mayor was commanded by writ to cause "all ships of **40** tons burthern and up to be provisioned with men and stores to repel any attempt at invasion," but before the preparations could be completed, the French, together with Genoese and Spanish allies, made a landing from a fleet of **50** ships, entered the town, and after plundering it, destroyed the greater part by fire. Many lives were lost, and a period of depression followed as many merchants were completely ruined and others sought places less prone to attack.

Mr. R. P. BIDDLE,
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The port suffered from the effects of pillage and destruction of the town, together with the inclination of Edward III to concentrate the bulk of the trade at Calais, and despite the increased facilities conveyed in a new charter by Henry IV, restoration of the previous standard of flourishing trade was not readily apparent.

In **1415** the army of Henry V was assembled and embarked at the port for France and the victory of Agincourt. Wars with France greatly affected commerce, and contention between the rival Houses of York and Lancaster provided a further hindrance to trade, yet in **1450**, despite these set-backs, Southampton ranked as the third port in the Kingdom—London being first and Bristol second.

Trade remained steady until Henry VIII's reign, when measures were taken to prohibit the exportation of wool, and in consequence, many of the Levant merchants, being unable to obtain the commodity they most needed, left the port.

Commercial activity now gradually declined for upwards of a century, but the port retained its importance for historic event, as is instanced by the reception of the Spanish and English fleets which escorted Philip of Spain when he landed at the Town Quay in **1554**, before proceeding to Winchester for his marriage to Queen Mary.

In August of **1560**, the port was again favoured with a visit by a reigning monarch, for Queen Elizabeth landed here from Netley Castle on her way to Winchester.

Sixty years later, Southampton's historic connections were further enhanced by the embarkation of the Pilgrim Fathers in the "Mayflower."

The Plague of **1665-1666** played havoc with the fortunes of the port, but the close of the century marked the turning point in the period of depression and traffic began to flow back and local industry improved.

The eighteenth century saw a good deal of shipbuilding in and around Southampton, and the port actively engaged in trade with the wine and fruit of Portugal; raw wool to Jersey and Guernsey, some of which was returned manufactured into coarse-knit hose; tar and pitch from Sweden; hemp, tallow, etc., from Russia; with coastwise traffic of iron from Wales, and glass, coal and lead from Newcastle.

Up to this time, commerce was dealt with at quays and hards, all of which were dry at low tide, but the advent of the nineteenth century saw the dawn of the dock era. Agitation by the Burgesses for the abolition of the Petty Customs dues, imposed upon all imports and exports by the Corporation, resulted in the Act of **1803**, creating a Harbour Board with jurisdiction over the affairs of the port, extending from just outside Calshot, up Southampton Water and the Rivers Hamble, Test and Itchen.

In **1832** the Board built its first pier to enable it to accommodate the steam packets which were running services to the Isle of Wight and Channel Isles. The pier was opened the following year, in the presence of Royalty, and was named "Royal Pier."

The year **1834** was destined probably to have greater influence on the history of the port, directly and indirectly, than any other, for it was the year of the Act which empowered the construction of the London and Southampton Railway.

Two years later, Parliamentary sanction was obtained by the Southampton Dock Company, with powers similar to those granted to the Harbour Board, which resulted in the opening in **1843** of Southampton's first dock.

The first new dock, being the largest in the country at the time, accommodated ocean-going shipping, and in **1846** the first graving dock was opened, making the necessary provision for overhaul and repair. Other docks, dry docks and quays were completed and put into use, but extension of the whole system of docks was vitally necessary on account of the increase in trade, the number of shipping companies attracted to the port, and the size and draught of vessels, and this development was made possible by a loan to the Dock Company by the London and South Western Railway Company (as the London and Southampton Railway had then become).

With the opening of the "Empress Dock" by Queen Victoria in July, **1890**, Southampton became the only port in Great Britain at which vessels of the deepest draught could arrive and depart at any state of the tide.

Probably the greatest factor in the history of the port's development occurred on November 1st, **1892**, when the whole of the docks undertaking passed into the hands of the railway company which was able to provide the necessary finance for the development and extension of the undertaking.

Natural Endowments

The Port of Southampton is very fortunately situated geographically, and is endowed by nature with certain specific advantages. It enjoys a sheltered harbour which is approached by a protected estuary, and, due to the remarkable features of the

* Paper read at Southampton on June 16th, 1939, at the Congress of the Institute of Transport, and reproduced by permission from the Journal of the Institute.

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local tides, shipping can be dealt with without recourse to any system of locks, such as is necessary at many other ports.

In the first place, there are the two high-water crests separated from each other by about two hours, and which occur twice during a twenty-four-hour day.

Then there is the "Young Flood" stand, which is an interruption of the normal tidal rise, and means that from $1\frac{1}{2}$ to 3 hours after low water there is a "slack water" period, when the tidal level is from 5-ft. to 6-ft. above low-water datum level. Thus during the twenty-four hours there are periods of "slack water" at a level navigable by all types of vessels, totalling seven hours in duration.

Various theories have been advanced in connection with the tidal phenomena, but Dr. Doodson, of the Liverpool Tidal Institute, considers that most of the features can be explained along the method of harmonic analysis.

Since the time of the Venerable Bede (eighth century), it has been held by many that one wave comes directly up the English Channel, causing the first high water, whereas the other has come round the Scottish coasts, down the North Sea and through the Straits of Dover, causing another high water. The past and present Hydrographers to the port have always maintained the substantial truth of this theory.

General Development

In the early years of the present century the total length of quay in Southampton Docks was 18,300-ft., and the deepest quay had a depth of water of 32-ft. at low water of ordinary spring tides. At the present time, the total length of quay is 31,082-ft., and a number of berths are dredged to 45-ft. below L.W.O.S.T. The considerable development which has taken place in less than 40 years will be appreciated from these figures, and it is true to say that at the present time the port can accommodate with ease the largest ships afloat.

The early part of this century saw the inauguration of a forward policy which is now culminating in the completion of the New Estate. The first major works undertaken were in relation to the Ocean Dock, which was completed and opened for service in 1911.

Soon after the Great War, it became apparent that it would be necessary still further to increase the facilities owing to the steady growth in the amount of shipping to be dealt with. In 1924, therefore, Parliamentary powers were sought for the building of a new system of docks. The site selected for this scheme was a bay on the River Test, about two miles long and half a mile wide, and extending from the Royal Pier upstream to Millbrook Point. The scheme included the construction of a quay wall about $1\frac{1}{2}$ miles long, running from east to west, and enabling berths to be provided for eight large ships in line on the south side of the wall, and providing about 400 acres of reclaimed land for the erection of sheds, warehouses and factories and the provision of the many other amenities of a modern dock. At the western end of this area has been built the King George V Graving Dock, the largest dry dock in the world.

One of the most interesting phases of this new dock scheme is the dredging which was rendered necessary. A channel, about two miles long and at least 600-ft. wide, has been provided from the original swinging ground of the Ocean Dock up to the eastern end of the new quay wall and throughout its length. The whole of the dredging involved necessitated the removal of 20,000,000 tons of material of various kinds. The manner in which this was used is most interesting and was, of course, determined by the nature of the material itself. The soft clay mud with which the estuary is overlaid was taken to sea for disposal. Below the mud, however, there was a stratum of gravel, and this was utilised for making banks or concrete. Below the gravel was other material which was conveyed through pipe lines to the area to be reclaimed, and this became the basis of the reclamation land. Before, however, this could be done, it was necessary completely to exclude the tide from the area to be reclaimed, and for this purpose a main bank was constructed which ultimately enclosed the bay and by a set of sluices, through which the tide could pass into and out of the reclamation area, it ultimately become possible completely to exclude the water.

The quay wall itself consists of a long line of 146 concrete monoliths, each 45-ft. sq., which are sunk to depths varying from 71 to 100-ft. These monoliths were placed on the main bank already referred to, and a continuous concrete face wall was then built above them. The result of this was to provide a quay 50-ft. in width, with all the necessary provision for crane tracks and rail access.

Behind this quay have been erected eight passenger and cargo sheds. These have been built in pairs, each pair forming one continuous building, 150-ft. wide, and varying in length from 1,274 to 1,666-ft. In the centre of each pair of sheds is a large buffet and lounge waiting-room. The buildings are single storey with walls of reinforced concrete and brick. The roofs consist of double cantilever steel trusses resting on two rows of braced steel columns supported on reinforced concrete piles. In addition to the rail track at the back of the sheds there is another in the front portion and two running the whole length of the quay. The quay is equipped with 28 electric level-luffing cranes, lifting 2 to 5 tons at a radius of 86-ft.

The whole estate is fully equipped with 26 miles of railway sidings, which are connected with the main line at the western end of the estate and with the old docks and main line at the eastern end. In addition, there are approximately four miles of vehicular roads.

The King George V Graving Dock is 1,200-ft. long and 135-ft. wide, and was constructed in a very short space of time. At the time that the decision to build was made in January, 1931, the site of the dock was tidal mudland. The area to be used was at once surrounded by a gravel enclosing bank, made watertight by means of inter-locking sheet piling. The bank was finished in 1931, and the site pumped out and excavation commenced. The work involved 1,258,000 cu. yds. of excavation and 456,000 cu. yds. concrete, and this work was all carried out between June, 1931, and April, 1933—in view of the complicated nature of the structure, a record achievement. The dock is equipped with two travelling electric cranes, one on the west side of 50 tons capacity and one on the east side capable of lifting 10 tons.

The pumping plant, which is situated on the western side of the dock, provides for both dewatering and impounding, and also for ejecting storm water. Pumps have also been installed for providing circulating water to ships, for fire-fighting and other purposes. The system of valves and pumps is so arranged that they can be operated by one man from a control desk.

Industrial Development of Southampton

A useful approach to this brief consideration of the port's industrial development will be provided by effecting a comparison between Southampton of 50 years ago and to-day. In the late 'eighties the port, then boasting a population of some 60,000 people, could claim no particular eminence among its contemporaries. This was not to be wondered at, when it is considered that the port's hinterland, the agricultural counties of Southern England, afforded little opportunity for development in an age which witnessed great expansion in Britain's industrial activities, centred in the North and Midlands, with resultant increased trade for those ports directly serving such areas.

To-day, however, the Southern Port has trebled its population of 50 years ago, whilst its rise, during this comparatively short period, to a leading position among the seaports of the country provides the strongest evidence of the important part which the past half century has played in the growth of Southampton, and more especially in its industrial development.

The mainspring of local industry is naturally the docks, and it is therefore not surprising that the past few decades which have revealed such marked growth in the size of the town have also been the most successful period in the history of the docks undertaking. Two factors have been largely responsible for the remarkable progress achieved in the shipping trade during these years, firstly, the acquisition of the docks by the railway company in 1892, which made possible the many improvements and extensions of shipping accommodation since effected, and, secondly, the initiative of that famous transatlantic shipping company, the American Line, which, by transferring its express New York service from Liverpool to the southern port in 1893, started the movement which led to Southampton's supremacy in the North Atlantic passenger trade. The significance of the past half century, so far as the docks is concerned, may be expressed briefly by the following figures relating to the amount of shipping tonnage entering in 1888 and 1938:—1888—2,376,213 gross tons; 1938—19,164,774 gross tons.

A number of other trades connected with shipping became established at the port during this period. Some of these, such as shipbuilding, and the manufacture of marine motors, developed independently of the general shipping trade, while others might be classified as subsidiaries to the shipping trade. The latter are mainly comprised of a group concerned with the manufacture of products, the raw materials for which are imported through the docks. Thus, under this heading are ranged the following local industries: electric cables, tobacco, margarine, seed-crushing, and timber saw-mills, these being representative of the group.

Also closely allied to the shipping trade is the business of ship-repairing, and several firms employ large numbers of workers, mostly within the docks where the periodical overhaul of the big liners provides a source of much employment.

An enterprise of considerable magnitude is that connected with the storage and refining of oil at the large depôts of a number of prominent oil fuel companies located within the port at Hamble and Fawley. Enormous quantities of oil fuel are supplied to the shipping using the port and, as is mentioned elsewhere in this paper, Southampton is one of the largest oil fuel storage centres in the United Kingdom.

As might be imagined, the section of industry only remotely related to, or entirely independent of, the maritime activities of

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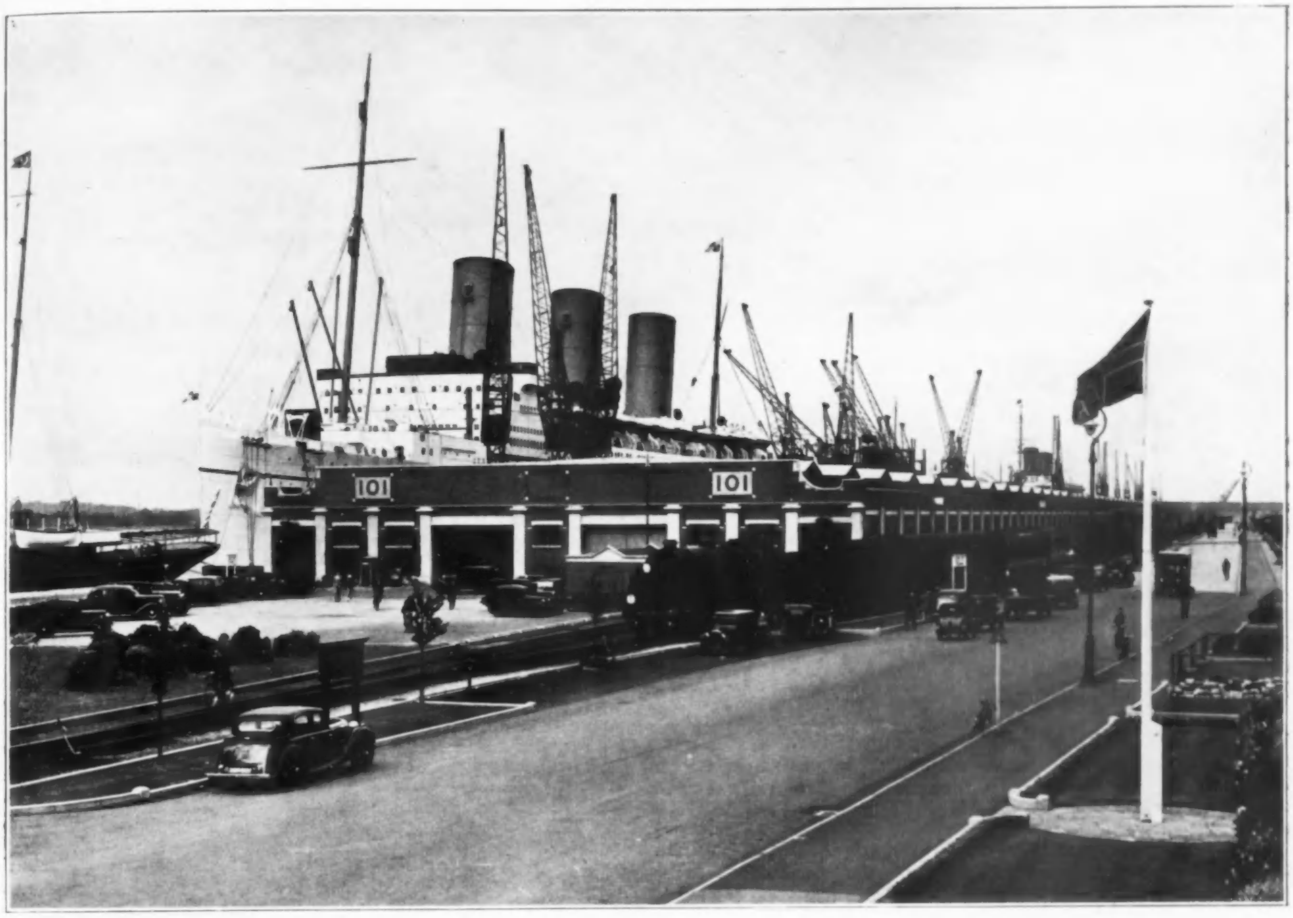
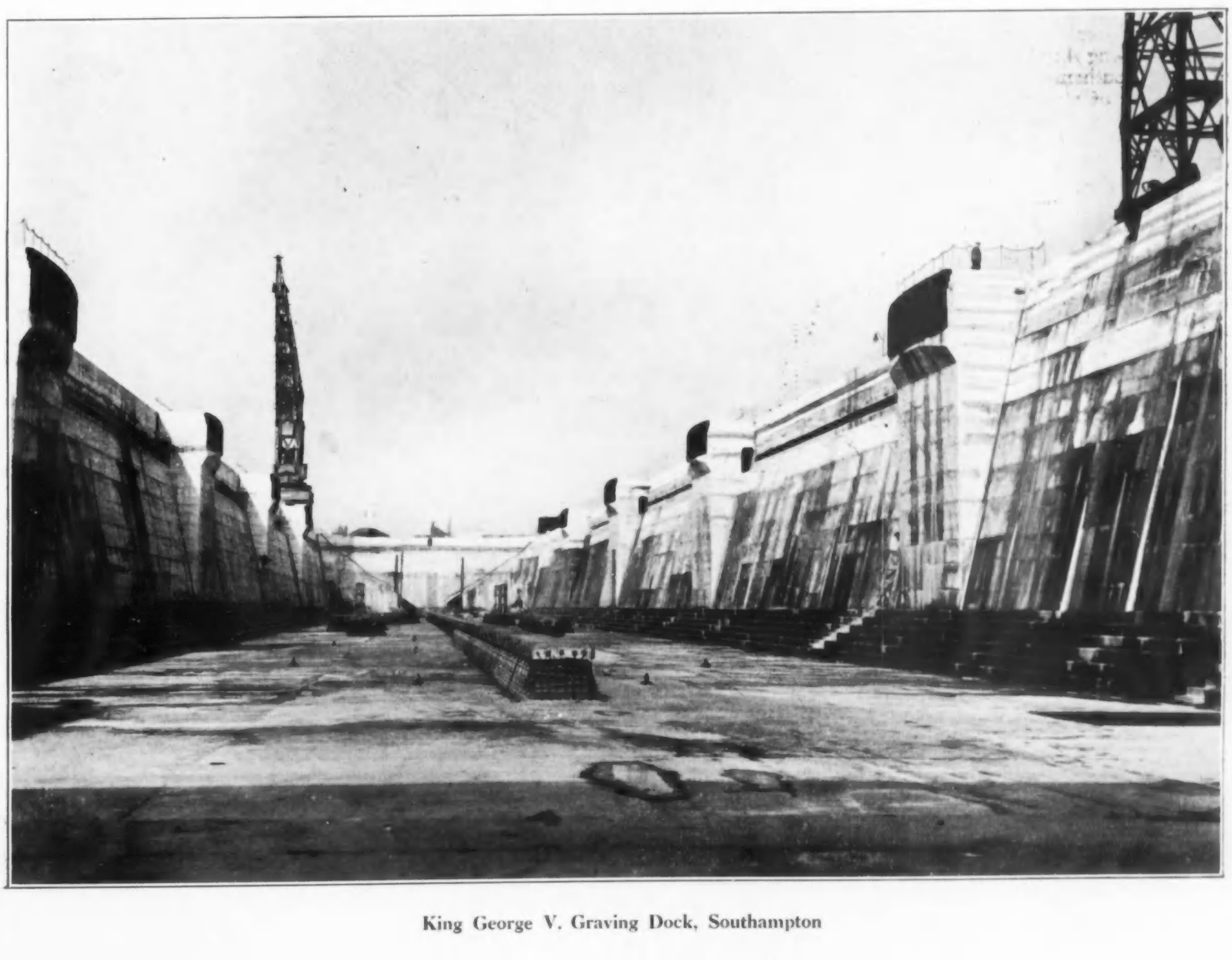


View of Docks Extension, showing Herbert Walker Avenue and "Empress of Britain" at 101 Berth



King George V. Graving Dock, Southampton

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the port is comparatively small. Within this group is the Ordnance Survey Department of H.M. Government, the manufacture of electrical apparatus, tooth paste and powder, chemicals, and seed packing and distribution. In the early post-war years the establishment of aircraft works at Woolston brought one of the most modern industries to the locality—the construction of marine aircraft.

The past five years have witnessed the commencement of a new and important phase in the development of the port's industrial potentialities. An ideal trading estate has been planned on a portion of the land reclaimed in connection with the docks extension scheme. This estate, with its advantageous transport amenities allowing direct access by railway, road, and deep water, is already achieving a degree of success which is calculated to advance materially Southampton's status as an industrial centre. The location of the estate on the dockside possesses obvious advantages for the manufacturer who either imports raw materials or exports finished products, and so it is that the trading concerns established here are mainly those related, more or less directly, to the shipping activity of the port. Examples of this most recently acquired group of industries are Messrs. J. Rank, Ltd. (Solent Flour Mills), Messrs. General Motors, Ltd. (Motor car assembly works), and Messrs. Montague L. Meyer, Ltd. (Timber storage and saw mills).

South African Citrus Fruit in Shed 101

Increasing recognition of the port's value as a regional centre for the distribution of various firms' manufactured products to Southern England has resulted in the opening of a number of distribution depôts here within the last few years. These include premises for such well-known firms as Messrs. H. J. Heinz Co., Ltd., and Messrs. Cadbury & Fry.

Perhaps one of the most important developments of recent years, however, has been the part played by the port in the world of air transport. Following the selection of Southampton as the temporary base for Imperial Airways Empire flying-boat services in 1937, it was in 1938 established as the permanent marine air base for the United Kingdom, a distinction of which the port may be justly proud. As a terminal for land-plane services, the town is also one of the principal United Kingdom centres, the municipal airport being one of the largest, best-equipped and busiest terminals in the provinces.

The foregoing brief review furnishes sufficient evidence to show that Southampton has attained a definite status in the industrial life of modern Britain. That the events of the post-war period have contributed so much to its development in this respect indicates, I think, the port's attunement to modern industrial conditions. Although the real significance of some recent developments, notably the leading part which Southampton is taking in its latest sphere of activity—air transport—cannot yet be assessed, it is certain that they are bound to lead to enhancement of its industrial position in the future.

Docks Extension. The "Bremen" at Berth 102

Shipping

Probably one of the most impressive features of the development during the last 50 years has been the increase, not only in the tonnage of vessels dealt with at the various great ports, but in the size of the vessels concerned, e.g., in 1892 the largest vessel using Southampton Docks represented a gross tonnage of 10,786 tons, whereas in 1937 this figure had increased to 81,235 tons.

Whilst it is not within the purview of this paper to review the various activities of the many shipping companies concerned, the growth in the size of vessels is one of the outstanding factors in determining the policy and development of the port, and the graph (Fig. 1) illustrates the position in the term of shipping dealt with.

Rates, Dues and Charges

The Port and Harbour of Southampton, which is vested in the Southampton Harbour Board, embraces the whole of the Southampton Water, River Hamble up to Bursledon Bridge, River Itchen and River Test. Dues are, therefore, payable to the Southampton Harbour Board for all vessels proceeding to the Southampton Docks, the Southampton Town Quay, or to any of the privately-owned wharves or quays declared to be within, or to form part of, the Port of Southampton.

Upon a vessel entering the Southampton Docks the following rates and dues are payable:—

Southampton Harbour and Board Charges—

Tonnage dues (based on net registered tonnage of vessel),
Boomage dues,
Harbour light dues.

Southampton Dock Charges—

Tonnage dues based on the net registered tonnage of vessel (excepting yachts which are charged on gross registered tonnage).

Landing charges on cargo. These charges are covered by a consolidated import rate according to the commodity handled, which includes labour receiving from ship, wharfage, placing in landing shed, sorting to prime marks, delivery to vehicle and haulage over dock rails. The rate also includes fourteen days' free storage, excepting certain traffics, such as timber and grain. After the free period of storage, a warehousing rate according to the traffic dealt with is incurred, and a weekly rental charge accrues.

Charges on cargo for export. Charges for the shipment of goods are also consolidated, the export rate covering haulage over dock rails, unloading vehicle, seven days' free storage, delivery to vessel and wharfage dues.

Overside delivery. Cargo is also delivered overside into lighters, or shipped from lighter to the outward-bound vessel, in which case overside dues are payable.

Cranage charges. Cranage charges which are incurred by the use of cranes lifting cargo from ship to quay, or from quay to ship, are usually paid by the shipping company.

Port of Southampton—continued

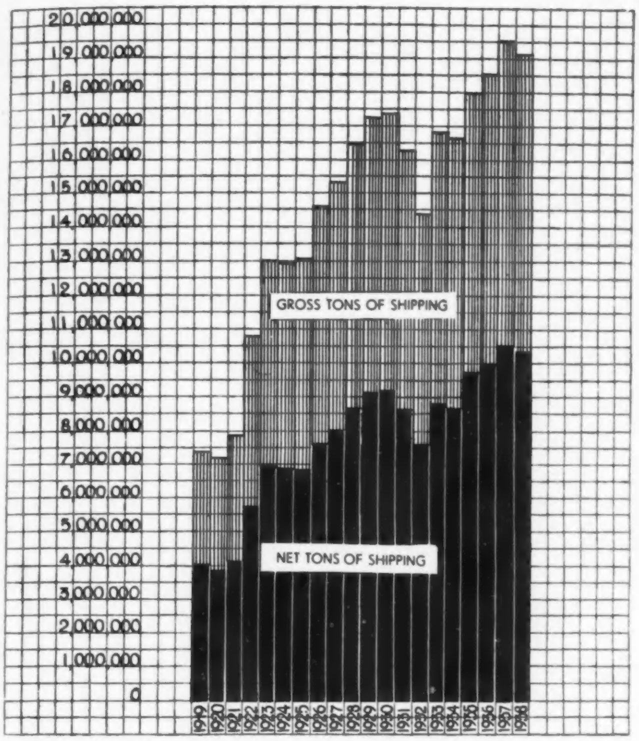


Fig. 1. Tonnage of Shipping Entering Southampton Docks 1919-1938

Southampton Town Quay—

Vessels proceeding to Southampton Town Quay are subject to the same Harbour Board dues as that of a vessel entering Southampton Docks, and also pay tonnage dues upon occupying a berth.

Landing and wharfage dues are charged on cargo landed, and charges are also raised upon the shipment traffic, together with wharfage dues according to schedule.

The Itchen Buoys are under the jurisdiction of the Southampton Harbour Board, and are usually used by vessels discharging timber.

The shipping at Eling on the River Test comprises small coasting vessels which discharge cargo at privately-owned wharves.

Cargo Trade

Southampton is accorded such universal recognition as a passenger port that this aspect of its activities is apt to overshadow its importance as a centre for cargo traffic. Nevertheless, it has achieved a prominent position among the leading cargo ports of the United Kingdom as is evident from the Board of Trade statistics relating to the value of import, export and re-export trade at the principal ports of the country. These show that in 1937—the latest year for which such information is available—Southampton's trade was valued at £73,700,000, an amount which was exceeded by only three other British ports, viz., London, Liverpool and Hull.

The trade of the port may be broadly classified under the following headings:—

(1) Traffic dealt with at Southampton Docks;
(2) Oil importations received at the depôts of various oil companies established at the port;
(3) Traffic dealt with at the Town Quay and various wharves along the Rivers Itchen and Test.

Of Southampton's total trade, which aggregates approximately 2,500,000 tons per annum, about 45% passes through Southampton Docks, rather more than 40% comprises oil and kindred imports, and the remainder represents traffic dealt with at the Town Quay and river wharves.

Apart from the oil traffic, practically the whole of the port's foreign trade is concentrated at the docks. Far exceeding in quantity any other particular import at Southampton, oil from the principal world sources, including Central America and the Persian Gulf, is brought in big tanker shipments to the Hamble and Fawley depôts of the British Mexican Petroleum Company, the Shell-Mex & B.P. Company, Ltd., and the Agwi Petroleum Corporation, Ltd.

The port is one of the chief centres for the importation and storage of oil fuel in the United Kingdom, and last year the huge amount of 1,108,000 tons of oils and blending distallates was received at the Southampton Water depôts mentioned above. Much of the oil is utilised for bunkering liners at the docks, while a considerable quantity is subjected to process for the procuration of valuable by-products.

Concentration of the overseas trade at the docks has been achieved through the continued effort to provide every facility for shipping traffic. The natural advantages of the port have been fully complemented by the provision of deep-water berths, modern equipment and direct railway access, thus affording ideal accommodation for every type of ocean-going vessel.

Considerably more than a million tons of cargo passes through the docks annually, and this important trade is largely of a "through" nature, i.e., goods for or from inland centres in various parts of the country.

The factors which have greatly assisted the growth of cargo trade through the docks may briefly be summarised as follows:

(1) Proximity of the port to London and Continental centres;
(2) Unrivalled railway system extending from the dockside to every part of the country.

Across the English Channel are a number of important Continental ports with which almost daily communication is maintained through the agency of regular steamer services, and it is as a result of Southampton's strategic position in relation to these ports that a large transit cargo trade has been built up. The value of Southampton's re-export trade is third among British ports to London and Liverpool.

By means of the express ocean steamships serving the port—75% of the shipping tonnage may be classified as liner traffic—and the speedy rail communication to all inland centres, Southampton has extended its effective hinterland for certain types of traffic into the industrial Midlands and North, and has gained an enviable reputation for speed. The remarkable growth of fruit and perishable traffic through the docks, and the big proportion of high-grade merchandise in the list of commodities dealt with testify to the benefit which the port has derived from this reputation.

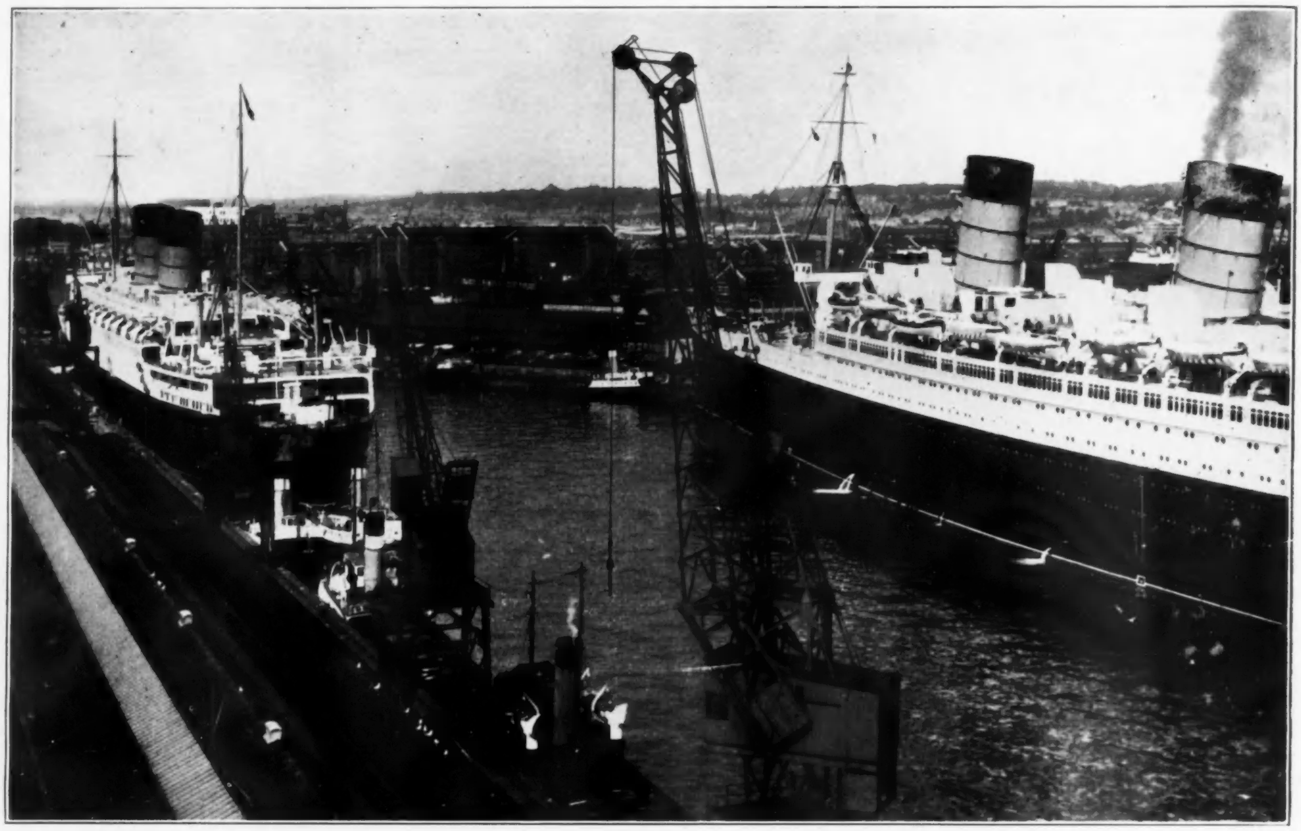
Southampton is one of the principal United Kingdom centres for the importation of fresh fruit, and the large number of productive areas from which shipments are brought include South Africa, South America, U.S.A., Canada, Channel Islands, Palestine, West Indies, Central America, Spain, Azores, Australia, New Zealand and France. The bulk of the South African fruit exports to this country are received at Southampton, and in 1938 more than 6,000,000 packages of deciduous and citrus fruits passed through the port from this source alone.

Drawn from many parts of the country, including the industrial Midlands and North, the tonnage of goods exported through the docks represents roughly one-third of the total amount of traffic dealt with, both inward and outward. The merchandise shipped is largely composed of the products of British industry, e.g., iron and steel machinery, rubber products and hardware from the Midlands, woollens and cottons from Yorkshire and Lancashire, respectively, hosiery from Leicester, and leather goods from Northampton. Together with a considerable quantity of goods in transit from near Continental ports, these freights are despatched to such world-wide destinations as U.S.A., South Africa, Japan, India, Dutch East Indies, South America and Canada.

In view of the importance which has attached to the development of trade within the Empire in recent years, it is interesting to observe that to-day approximately two-thirds of the overseas trade of the port—exclusive of oil imports—comes under this heading, compared with 50% ten years ago.

Fig. 2. Diagram showing the extent and nature of the cargoes imported through Southampton Docks during 1938

Port of Southampton—continued



Ocean Dock, showing Cunard White Star Liners "Mauretania" on the left and "Queen Mary" on right

The comparatively small portion of Southampton's freight trade which is carried on at the Town Quay and river wharves is, as has already been stated, largely coastwise, and the traffic handled is, with little exception, local in character. Much of the traffic is dealt with at the Town Quay, which is under the jurisdiction of the Southampton Harbour Board, and in 1938 a total of 145,000 tons of cargo was imported and exported here. Several shipping companies operating coastal services make a contribution to the trade at the Town Quay, while a survey of the foreign trade carried on shows that beside a regular monthly steamer service with Gothenburg, by which manufactured wood goods and paper traffics are received, a certain amount of freight comes from near Continental ports. A considerable percentage of the general cargo traffic between Southampton and the Isle of Wight is also centred at the Town Quay.

Dotted along the banks of the Rivers Itchen and Test are a number of wharves where small coastal and Continental steamers carry on a trade which, although not of large proportions, reveal a big range in types of cargo handled. Coal, beet sugar and potatoes are some of the freights from United Kingdom ports, while building materials and fertilisers are specimen traffics from the Continent.

A number of timber firms have premises abutting upon the waterfront on both rivers, and during the season receive shipments of softwoods from the Baltic. As a rule, the vessels which carry these cargoes are too large to discharge at the river wharves, and so they discharge into barges at moorings near the mouth of the River Itchen, the laden barges being towed to the up-river depôts of the various firms.

(To be continued)

Otago Harbour Board, New Zealand

Excerpts from Chairman's Annual Report for the Year ended September 30th, 1938

Trade and Shipping

It is satisfactory to report that the volume of trade which passed through the port during the year has exceeded all previous figures, reaching a total of 484,798 tons, as against 452,215 tons for the previous year and 464,508 tons in 1924-25, which held the record until last year. The increase is accounted for by imports, which increased by 43,852 tons on the previous year's figures, while exports showed a decline of 11,269 tons, the items mainly responsible being wool and fruit.

The imports, however, totalled 359,398 tons, creating records both in the inter-colonial and coastal and in the oversea cargo tonnages.

The shipping arrivals also created a record, totalling 1,225,830 tons net register, an increase of some 40,000 tons over last year, which at 1,186,107 tons held the previous record. The principal increase was in the overseas section, which showed an advance of 23,000 tons.

Revenue and Expenditure

As would be expected in view of the increases in trade and shipping, the improvement was reflected in the revenue, this also reaching its highest level to date, viz., £208,665, nearly £19,000 in excess of the previous year. The advance in the Harbour Improvement Rate, however, which came into operation on January 1st, 1938, accounted for £8,200 of the increase. The Board was thus able, in spite of increased costs, to continue its harbour improvement programme, and at the same time to transfer £10,700 to special funds, £2,750 as a special contribution to the Dredge Loan Sinking Fund, and £17,300 out of the year's revenue to the Special Works Reserve Fund, this transfer being mainly on account of works estimated for but not executed or only partly completed.

Works in Hand

The reconstruction of Birch Street Wharf is proceeding steadily, and a few months should see the whole of this wharf completed and in use. The widening of the Leith Canal is also progressing satisfactorily.

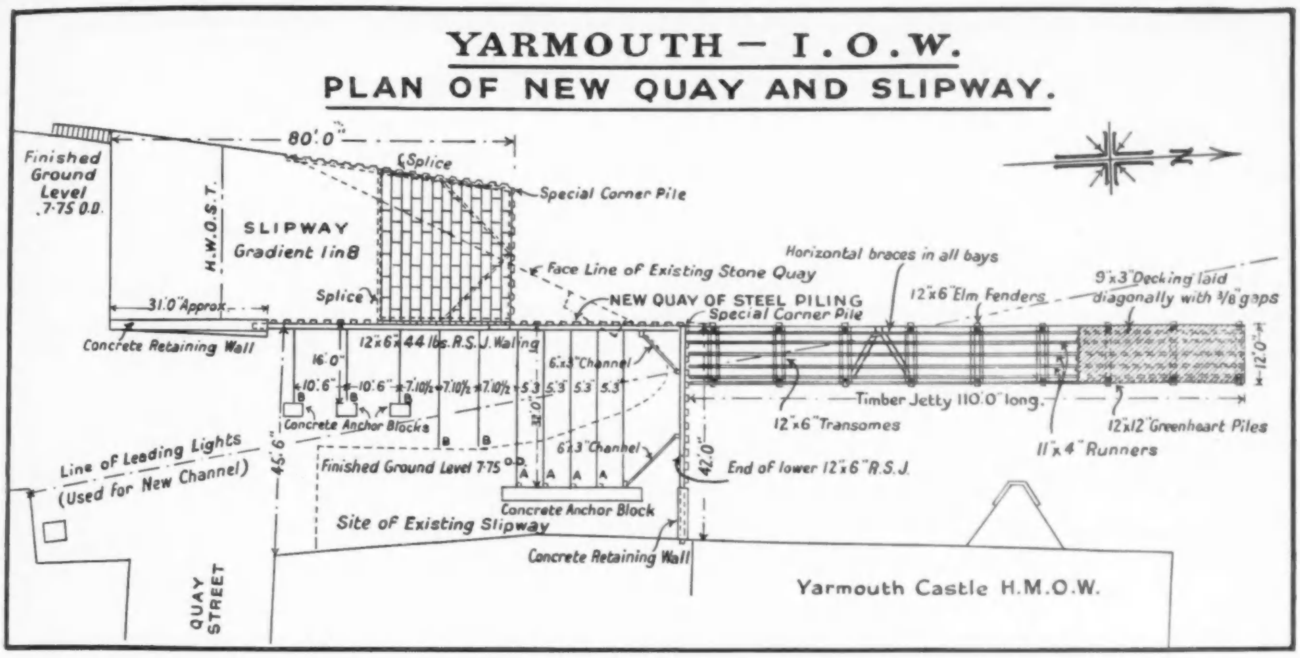
The new building for the accommodation of the Customs Wharf Staff provides a very necessary facility, both to the business community and to the staff concerned.

The flush-decking and strengthening of the south side of George Street Pier has been completed and provides a much needed improvement to the Port Chalmers berthage. It is proposed to deal similarly with the north side after the close of the present export season.

Dredging operations have been centred largely at the Heads, Deborah Bay and the Victoria Wharf. The Board is finding difficulty in keeping pace with the constant dredging demands consequent upon the increasing draft of vessels entering the port.

The reclamation of Mussel Bay is proceeding steadily, and it is anticipated that the area will be filled up to the required level during the present financial year.

The report is signed by Mr. W. Begg, Chairman.



*The Construction of Slipways at Lymington and Yarmouth**

By J. CAESAR, B.Sc., Stud. Inst. C.E.

(continued from page 297)

WORKS AT YARMOUTH

The town of Yarmouth is situated in the north-west corner of the Isle of Wight, and is the only passenger and cargo port serving that end of the Island. Whereas the pier extends into the Solent some 730-ft. northwards from the Castle, the Town Quay is situated on the west side of the Castle and is protected from the westerly gales by a breakwater, which forms the opposite and left-hand margin to the mouth of the River Yar.

The old quay was built of stone and ran from north to south, with a length of about 290-ft., of which only 50-ft. at the north end was accessible for small craft at all states of the tide. Between the quay and the Castle and joined to both was a stone-paved slipway, 70-ft. long and 17-ft. wide, which dropped from the end of Quay Street. This served as a landing stage for motor traffic arriving by barge from Lymington.

Under the former system of transportation, wheeled traffic and cattle could be off-loaded or shipped at low tide from the natural bottom at the toe of the slipway. Since the harbour was not used by large vessels on a constant service, as was the case at Lymington, no dredged channel was maintained to give access to the quay. Consequently, any new scheme involving a ship of comparatively large dimensions must carry the cost of dredging an approach channel.

The scheme adopted and shown in the plan above was to provide a straight line of quay 227-ft. long, nearly parallel to the Castle wall and in a direction N. 10° W., originating from a point in the old quay 6-ft. south of the line of Quay Street. This point forms the head of the new slipway at the existing quay level of 7.75 O.D. With a slope of 1 : 8, similar to that at Lymington, it falls to −2.25 O.D., a point 6-in. above L.W.O.S.T., where its minimum width is 25-ft. The quay wall proper is returned at right angles 35-ft. north of the toe and joins up with the Castle wall across the mouth of the old slipway. The rectangular quay space thus formed was constructed at the old level, while the remainder of the straight face takes the form of a timber jetty 112-ft. long, and at a level of 10.50 O.D.

Design of the Quay Wall

A design for the steel piling was adopted similar to that used for Lymington. Here the quay level is only 2-ft. 9-in. above H.W.O.S.T. and the dredged channel 7-ft. 6-in. below L.W.O.S.T. Details are shown in Fig. 5.

The face of the piling having a maximum retained depth of 18-ft., an outward thrust of 3.76 tons is developed on the back of the wall with a further thrust of 3.90 tons at the toe. This is counteracted by a pull in the tie-rods of 2.19 tons, placed 4-ft. 6-in. below the surface and a resistance of 5.47 tons over that portion below dredging; each per foot run of wall.

Reversal of Bending Moment occurs at a point 1-ft. 3-in. below the dredged level, while maximum bending is situated 12-ft. 6-in. from the top and has a value of 85.6 tons ins. This is amply covered by the section modulus of Larssen No. II steel piles, and Frodingham Hoesch piles of No. II section.

It must be borne in mind, however, that the nature of the filling behind the stonework to the quay was very uncertain. This resulted in the adoption of material, with an angle of slope of 30° as the safe medium for earth pressures. In the course of construction as excavation for the slipway proceeded ahead of the piling, the last 40-ft. of quay proved to be solid concrete and sufficiently stable to support the pile-driving frame. In dealing with material of this composition, any theoretical design involving earth pressure and its recognised assumptions must necessarily break down.

This design proved adequate for that section of the wall north of the concrete nose, but, although filling was dumped behind the main piling, it is doubtful whether the full load is developed in the ties.

As at Lymington, the length of the piles could be decreased as the level of the ground forming the slipway nose. It was decided to use steel piles of the Frodingham Hoesch type, Section II, as this section gives a better strength/weight ratio and could be delivered by the makers without undue delay. A similar specification to that for the piles at Lymington was employed.

For the main section 30-ft. piles were driven to a depth of 12-ft., and these decreased in length to a minimum of 10-ft. at the half-tide level on the slipway.

Special fabricated piles are driven at the junction to the slipway and at the corners of the main wall and the slipway piling.

The waling is made up of a 12-in. by 6-in. steel joist, clamped to the piles 4-ft. 6-in. below the top to take horizontal bending on its major axis. All ties were at this level, and over the deep section of wall are of 1½-in. diameter and spaced 5-ft. 3-in. apart, taking a load of 13 tons each. There were anchored to a block of concrete 2-ft. 6-in. by 3-ft. 6-in. in section, 28-ft. long, and placed 32-ft. back from the face of the piling.

Two tie bars at 7-ft. 10-in. apart and two more at 10-ft. 6-in. apart, bring the total up to ten over the 85-ft. length of quay, the first 31-ft. at the head of the slipway being taken up with concrete retaining wall.

Construction of the Quay and Slipway

Very little information could be obtained regarding the foundations to the old quay. Improvements carried out about 1912 took the form of extending the old stone and masonry wall

* Paper read before the Southern Association of the Institution of Civil Engineers on February 2nd, 1939, and published by kind permission.

Construction of Slipways at Lymington and Yarmouth—continued

northwards with a mass concrete nose. This was believed to be standing on a number of timber posts, the bottom of the concrete being a few feet below low-water level. Before work started, this concrete extension showed signs of falling out seawards, and subsequent excavations for the new crane foundations proved the original assumption to be correct.

A preliminary survey was carried out in May, 1937, and work started on Thursday, August 19th, when excavation was commenced along the line of piles. Any concrete or stone here had to be removed, whatever the depth, before piling could begin. All loose filling was removed from the site of the slipway, leaving the shell of the old quay to protect the work from excessive wave action.

this, the two piles being driven were firmly bolted together through the flanges, along the centre line, while an angle waling was bolted on the outside of the piles, at the top, after they were driven.

When driving beyond the limits of the old stone quay the piles proved very satisfactory, both in use and finished appearance.

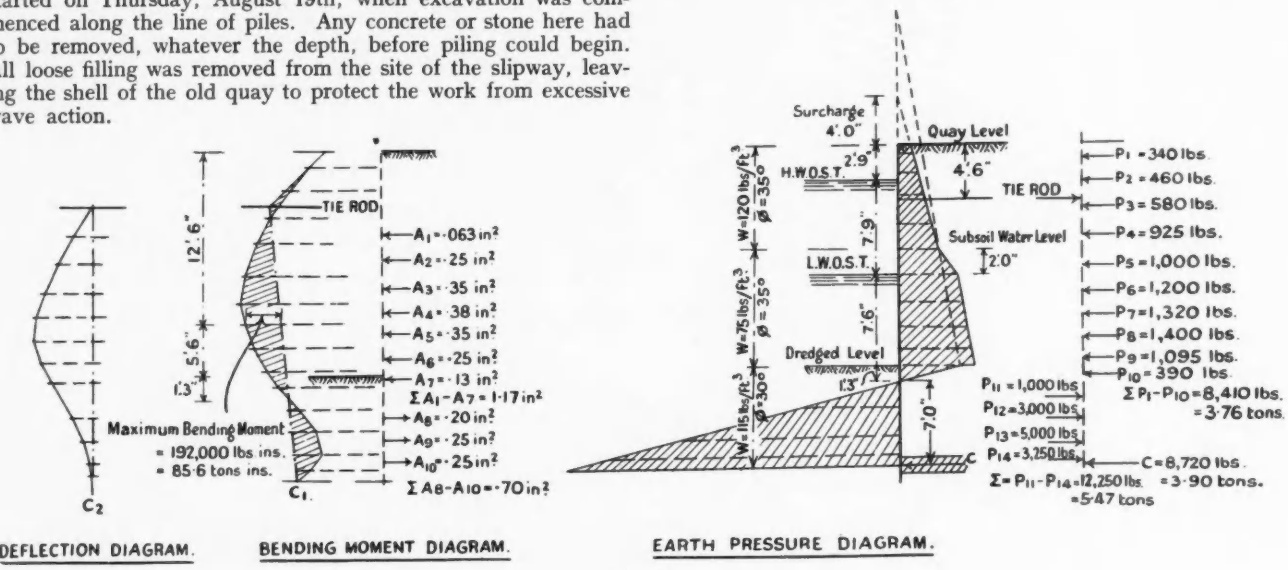


Fig. 5

330 cu. yds. were removed from the quay, of which about 30% were mass concrete or masonry. Blocks of the latter, 2-ft. square and 1-ft. thick, set in the line of the piling, presented difficulty in removal.

Pile-driving commenced on Friday, September 17th, at the south end of the main quay wall, and proceeded northwards for 30-ft. before any serious obstruction occurred. Fig. 6. Here the shell of the stone wall was encountered below the excavation level for the slipway, and progress in driving was dependent on the removal of these foundations. As the wall proceeded beyond the toe of the slipway, driving was governed more by the tides, and divers with grappling hooks were employed for the removal of obstructions. A breaker, improvised from a 20-ft. length of 90-lb. rail cut at the end to form a chisel, proved very effective for loosening material when used with the 30-cwt. hammer ahead of the piling.

The Hoesch section of steel pile differs from the Larssen in that it is of the Z pattern and makes use of a male and female clutch. The junction occurs in the face line when the piles are driven, and is so designed as to make this a flush surface. A pile of this section derives its section modulusm not by the thickness of metal in the web, but by making use of this position for the clutches in conjunction with a light box section. The piles were driven in pairs with the box of the combined section facing outwards, having the independent portions of the clutch against the inside guide walings, the male always leading in the direction of driving.

Difficulty was experienced in driving the light-section piles under the rather trying conditions. With resistance above the normal at the toe, a "concertina" effect was apparent, the pile being driven tending to stretch the top of those already in place. It is probable that, in driving, a large bending stress was set up in the angle of the web, since the line of pull was along the back face, causing the pile to distort. To overcome

Fig. 7 shows the new quay wall and the old quay before filling operations.

Thirty-eight tons of steel piling were driven, and the steel used in the walings and ties involved a further 11 tons. There are 20 tons of concrete in the anchor blocks, and 37 tons in the two retaining walls. The quay is finished with concrete 4-in. thick and reinforced. There is a fall of 4-in. from front to back to dispose of surface water in a 6-in. drain provided for that purpose (Fig. 8).

A 7½-ton hand-operated crane is installed at a point 21-ft. north of the toe of the slipway, its centre pin being 8-ft. back from the face of the quay. In view of the unstable condition of the concrete nose to the old quay, piles were driven to support the crane, after a hole to receive them had been excavated through the concrete. A 10-ft. sq. hole was cut in the concrete down to 2-ft. below L.W.O.S.T. Beneath this, bags of cement and sand were apparent, and the four piles, in the form of 12-in. by 6-in. R.S. Joists 20-ft. long, were punched through these.

The concrete to the quay being so loose, any direct weight on it, such as the crane and its load, in this case amounting to some 12 tons, would create a considerable additional earth pressure acting horizontally on the steel piling. The scheme adopted of driving these piles obviated the risk of any such earth pressure, not only by taking the dead weight of the crane, but also supporting it against any tendency to overturn.

The north section of the wall, 42-ft. in length, was also anchored into the main block, and the piles here were driven from floating plant. No obstruction was encountered in driving to within 10-ft. of the Castle wall. The junction to the stone wall is made up of a mass concrete retaining wall, 10-ft. in

Fig. 6. View showing the commencement of the Steel Pile Wall from the Head of the Slipway

Fig. 7. The new Steel Piling and Greenheart Piles from the Jetty, showing the old Stone Quay Wall
Yarmouth Castle and Pier are also shown on right

Construction of Slipways at Lymington and Yarmouth—continued

length, and of a rectangular section 3-ft. wide. Upper and lower walings act as horizontal beams between the Castle wall and the steel piles, and the concrete is reinforced vertically with steel rails at 3-ft. centres.

This northerly face of the new quay, thus formed, meets the Castle wall 1-ft. south of a line denoting the property controlled by His Majesty's Office of Works. In the later stages of the work, it was capped with a pre-cast parapet, and an ornamental stone wall to protect the quay from splashes resulting from wave impact.

The slipway proper is constructed on exactly the same lines as that at Lymington. With a toe 25-ft. in width and the crest 34-ft., a slope of 1 : 8 was adopted to suit the requirements of the new vessel. Steel piles, 10-ft. in length across the toe and ranging from 10-ft. to 20-ft. up the west wing, form the supports to the filling required outside the line of the old quay. These piles are stiffened by 6-in. by 6-in. angle walings, and are similarly braced across the corners.

Where these walings were fixed to the main quay wall no access could be gained to the back of the steel piles. 1-in. diameter bolts with the heads forged to form a 3-in. by 1-in. Tee were used at every outward facing pile. A corresponding hole was cut in the face of the pile and, after insertion, the bolt head was turned through 90°. Friction on the back of the pile and the stony material behind it, prevented any twist when the nuts were tightened into the walings.

The wing piles meet the old wall where an angle occurs in it, and form a straight line on the west side of the slip, at an angle of 10° with the main wall. As at Lymington, the surface is paved with pre-cast blocks between the toe and half-tide level, above which the surface is made good with reinforced slab concrete 6-in. thick.

Five greenheart bollards at 15-ft. intervals are provided for the vessel's use, and stand 4-ft. 6-in. above the quay, the face being flush with the piles. These are exactly similar to those at Lymington, and are halved at the base to form the fixing behind the walings.

The concrete coping with its bullnose rail forming the quoin is identical with that already dealt with and needs no separate mention here.

The Timber Jetty

In order to provide adequate mooring space for the vessel at all states of the tide, a further length of at least 100-ft. of quay was essential, beyond the limit of the steel piling. This latter could not be extended and returned at a more northerly point by reason of Yarmouth Castle being an ancient monument. A pier presented the best and most economical solution to the difficulty, and a timber jetty was constructed 110-ft. long and 12-ft. wide in line with, and forming a continuation of the quay wall.

Fig. 9. The completed Quay, showing the toe of the Slipway at Low Water

Eighteen greenheart piles, 35-ft. in length and 14-in. square section, were driven with a lateral interval of 10-ft. and in bays along the jetty of 13-ft.; the two first being 6-ft. north of the steel piling. Dock level was fixed at 10.50 O.D., 2-ft. 9-in. above the existing quay level, thus giving more clearance above H.W.O.S.T. All piles were driven to the deck level, except alternate ones on the front row, five in all. These were left standing 3-ft. 6-in. above the others, and were afterwards wrought, to act as bollards. The piles were driven 10-ft. into the river gravel, the whole length of each one being utilised and an average set of ½-in. to the blow of a 30-cwt. hammer falling through 6-ft. was recorded.

Greenheart was chosen for the piles in order to withstand, to a certain extent, the action of marine organisms. When extracting the fender piles which stood against the face of the old quay, evidence was found that teredo had attacked the timber.

12-in. by 6-in. transomes, bolted through the piles, support the deck runners, and 11-in. by 4-in. bracing gives strength in the lateral direction. Longitudinal bracing of the same size, in all bays, and similar walings 10-ft. below the deck, provide stiffening along the jetty.

9-in. by 3-in. deck boards of red deal are laid diagonally with

Fig. 8. View showing the Slipway on the outside of the Steel Piling

a spacing of ⅜-in. and, together with the runners below it, are not attached to the piles in any way. Any blow received on the front piles is shared with those at the back by transmission through the transomes and bracing. Special braces of 12-in. by 6-in. section are fixed under the deck runners so that, in the event of an excessive blow occurring on the walings between the front piles, it is transmitted through them to the piles at the back.

All the structural members in the jetty are of Oregon pine, and were creosoted under pressure to absorb from 5-7 lbs. of creosote per cu. ft. The deck is tarred and sanded on the top side.

The face line to the quay is continued by 12-in. by 6-in. fenders of elm on the forward row of piles, and these extend from deck level to 3-ft. below L.W.O.S.T. These were fixed by means of side cleats in the shape of railway fish-plates bolted to the piles and the fender, thus making renewal of the latter an easy matter.

An expansion joint between the quay and the jetty allows for the flexibility of the timber structure under sudden impact. This is made up of a section of decking, 5-ft. long, at the same level as the quay, and supported on two steel channels let into it horizontally. Above this, steps give access to the jetty. A longer flight of steps is constructed at the rear, as part of the structure, and gives an approach to the quay for small craft.

Dredging

The existing leading lights controlling the entrance to the old slipway were utilised to form the guides for the approach channel to the new one. The channel is 60-ft. wide at the toe of the slipway, and has a slope of 1 : 5 from the toe level to the deep-water level of 7-ft. 6-in. below L.W.O.S.T. It continues along the line of the new quay for a distance of 330-ft., increasing in width to 100-ft. before picking up the line of the leading lights. It then continues along this centre line a further distance of 400-ft. until 7-ft. 6-in. of water is attained by the natural level of the sea bed. A total of 7,900 cu. yds. of river gravel were removed by bucket dredger to form this entrance to the harbour. Fig. 9 shows the scheme as it approached completion.

Conclusion

Before the completion of the work in May, 1938, the Yarmouth Pier and Harbour Commissioners provided new waiting rooms and harbour offices by alterations to the neighbouring property. The new quay has a length of 145-ft., which can be used by vessels of 7-ft. draught, or under, at any state of the tide. It is now served by working, or parking space of 1,925 sq. yds., not including the slipway. Equipped with water and electric light, it now presents one of the most easily-worked and accessible harbours in the Isle of Wight. There is no doubt that the increased traffic returns and the popularity of this, the shortest route to the Island, will, in the future, more than justify the enterprise shown by the Southern Railway Company and the Yarmouth Pier and Harbour Commissioners in developing these two harbours.

The Port of Oslo

Chief Norwegian Shipping Centre

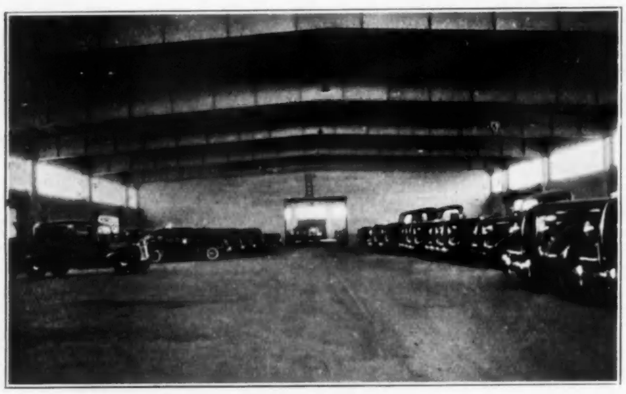
By Y. KJELSTRUP, General Manager of the Port of Oslo

(continued from page 285)

Sheds, Warehouses and Mechanical Equipment

All quays are equipped with sheds or warehouses according to the requirements of the traffic. Along the Akershus shore in Piperviken and at certain places in Björviken, where local and coastal traffic is still carried on, there are some open and some enclosed sheds that are only intended to provide shelter for the goods in the short interval between their discharging and fetching or delivering and loading into the ship.

On the Vippetang Quay a three-storeyed warehouse was built in 1915-16, partly of reinforced concrete and partly of timber, with a ground area of 50 by 16 metres. The ground floor is used as an ordinary quay shed, while the first and second floors are used as customs warehouses, and are furnished and equipped accordingly. On the level of the first floor and running along the side of the warehouse nearest the quay, there is a 1.5 metre wide platform upon which goods can be landed direct from the ship.



Interior of Shed—Filipstad Quay

The sheds on the Grönli Quay (see page 282 Aug. issue) were erected in 1914 and 1927 respectively. They are specially built for the storage of export goods, particularly paper and cellulose, and are dimensioned and equipped for this purpose. The first is 140 metres long and 18 metres wide in one span, and has a height to the cornice of 9.25 metres. Pillars and roof supports are of iron, otherwise boarding is used. Sliding doors are used in two storeys. Both at the front and at the back of the sheds are three railway tracks. The shed is furnished with two transporting cranes for discharging from railway waggons into the shed with a lifting capacity of 1½ tons. The south shed, which was built in 1927, has a width of 23.6 metres, also in one span. It was planned to be 170 metres long, but for the time being has been built to a length of 80 metres. The method of construction and crane equipment is the same as in the case of the shed first erected.

In 1923, a four-storeyed warehouse was erected on Pier No. 1 in Björvika, as shown in fig. 7. It is built of reinforced concrete, with a ground area of 102.5 by 30 metres, and a total floor area of 12,200 sq. metres. Along the length of the warehouse facing the sea, discharging platforms are provided outside on the level of each floor. The warehouse is equipped with ten electric elevators and six sack chutes, and the first floor is equipped for the clearing of goods through the customs.

In Björvika, further in, on Langbryggen, a two-storeyed warehouse has recently been completed, which is the first of a series of similar type projected. It has a ground area of 56 by 19 metres, is constructed of reinforced concrete, and is supported on a foundation of steel piles rammed down to the rock. In order to prevent corrosion, the steel piles are alloyed with 5% copper. In a set-back second floor a dining and waiting hall, with the necessary sanitary conveniences, has been fitted up to accommodate about 220 workmen. The warehouse is, moreover, furnished with three electric elevators and with steel rolling doors, that are opened and closed by compressed air.

The platform outside the set-back second floor is connected by an elevated railway, with the large warehouse lying to the south, Oslo Havnelager (Oslo Bonded Warehouse). This is an eleven-storeyed building, which was erected in the year 1916-21. The ground area is 140 by 24 metres, and the total floor area approx. 30,000 sq. metres. At the side of the warehouse, overlooking the quay, a platform, 10 metres wide, has been constructed on the level of the second floor, and this platform has been extended northwards over Langbryggen and ends on the roof of the above-mentioned warehouse on the northern part of Langbryggen. This discharging gangway and platform carries the tracks of electrically-driven transport trucks; the goods from the vessels are discharged into the trucks, which are driven straight into the warehouse elevators and are transported to the different store rooms. This affords a welcome relief for the traffic on the quay underneath. The making of foundations for this warehouse was rather difficult; the ground was soft and the rock lay at depths from 15 to 25 metres below zero water level. It proved impossible to get deeper than 8-9 metres below ground level, even with the help of pile-planking or sunken cylinders, as the clay came up again as quickly as it was excavated. At last, it was necessary to rest satisfied with the method of digging each foundation pit as deep as possible, i.e., 8-9 metres, and thereafter driving fourteen reinforced concrete piles close together, down to the rock. The section of the piles was 0.4 by 0.4 metres, making in the aggregate 2.25 sq. metres. The load capacity of each was 50 tons, and thus for each foundation, 700 tons. The tops of all the foundations were then moulded in a concrete slab, which formed the cellar floor. The building, otherwise, is constructed wholly of reinforced concrete, and is well equipped with elevators and other means of transport.

The warehouse was built by a private company, who have leased the ground from the Port Authority at a yearly rental. Among the conditions of the concession, there is a provision that the building shall revert to the Port Authority after the expiry of 60 years, and that the Port Authority shall have the right to exercise control as to the maintenance of the building, charges, etc.

The quays, for the rest, are furnished with quay sheds, larger or smaller, intended for the temporary shelter of goods that have arrived or await shipment. In the case of the quays for foreign trade, these sheds are gradually being replaced by warehouses of several storeys, intended also for storage. The plans for the next few years thus include five sheds on Langbryggen of the type that has been described in some detail above, and also two large warehouses on Pier No. 2.

During last year two large sheds, each with a ground area of 3,000 sq. metres, have been erected on the Filipstad Quay. They are both single-storey buildings, 100 metres long and 30 metres wide. The roof rests upon supports of iron in one span, and walls and floor are of reinforced concrete. All gates are of the steel-rolling type, actuated by compressed air.

Special plant for the discharging and storing of grain has been erected on Pier No. 3 at Vippetangen (see next page). The first grain silo, with a storage capacity of 10,000 tons, was built in 1913 by a private company with a concession for 25 years. For discharging, a mechanical elevator was used originally, and the grain was conveyed from this through an underground canal into the silo. Later on, this elevator was replaced by a modern pneumatic discharging apparatus, which had a capacity of 120 tons per hour, the conveyor band, after alteration, being carried in a channel above the quay. The whole plant was taken over by the Port Authority in 1934, and leased to the State Grain Office, which at the same time received permission to build a new grain silo with a storage capacity of 15,000 tons. A new discharging elevator was procured, in addition to that in use, and the capacity of each increased to 150 tons per hour. A loading apparatus was also bought. The total storage capacity of the plant is 25,000 tons, and its discharging capacity 300 tons per hour. It is carried on wholly for the account of the State Grain Office, but the Port Authority has the final control of all expenses.

Of other special plant in the port, Chr. Matthiessen's banana ripening store on the Brandskjær Pier to the extreme west of the port may be noticed. A concession having been granted by the Port Authority, a warehouse building and ripening plant for bananas, with a ground area of 2,275 sq. metres, has been erected. On the quay outside a discharging apparatus for bananas has been fitted up which, in the course of five or six hours, can convey 8,000 bunches of bananas into the ripening store.

Technical Equipment, Cranes, etc.

The first electric slewing crane used in the harbour was bought in 1908 and delivered by the firm Ransomes & Rapier. It was a stationary 20-ton crane, which was set up on Pier No. 2 at

Port of Oslo—continued

Vippetangen, where it is still in use. During the next few years, Norwegian firms delivered 3 and 5-ton electric portal cranes with fixed jibs with a height of 16 metres and working radius of 11.7 metres. As vessels increased in size, the cranes followed suit, and the cranes that were bought in 1920 and thereabouts had a height of 23 metres and swing radius of 15 metres. Most of the cranes are built to lift 3 tons, some also to lift 6 tons. Since 1928, the new cranes are provided with luffing arms, whereby the working radius varies from 8 to 15 metres, while the height varies at the same time from 26 to 23 metres, with horizontal movement of the load. In the same year was commenced the reconstruction of the older types of crane, which were also given luffing arms. The last 12 cranes, ordered in 1937, are rather larger still, having luffing arms, the working radius of which varies from 19 to 26 metres, while the height of the crane from the quay is altered from 42 to 32 metres. The lifting capacity is 4 tons at the least radius, diminishing to 2 tons at the longest radius. These cranes are exceptionally advantageous for direct transhipment from ship to ship on account of their great radius of action.

On the quays of the port there are at present 90 electric portal cranes in all, 62 of which belong to the Port Authority. Among the private cranes that have been erected on the Authority's quays, and in some cases on private ground, all of which, however, are available for use for the purposes of the ordinary traffic of the port, there is one 100-ton crane belonging to Akers Mekaniske Verksted. There are, it remains to be said, eleven modern coal discharging apparatus with a discharging capacity of approx. 90 tons per hour. They have all been erected with the permission of the Port Authority, partly on private quays and partly on the quays of the Authority's adjoining areas that have been leased to those concerned by the Port Authority. Of these discharging plants, special mention may be made of the coal discharging plant belonging to the Norwegian State Railways, and lying at Grönlien, furthest east in the port area. The quay, which has been described in some detail (page 284) is furnished with three railway tracks, and on the inner side of these, a coal silo with a storage capacity for coal of about 2,000 tons. Discharging is carried out by two coal discharging apparatus, and may be either direct into railway waggons through a sorting plant in the discharging gangway or into the slio. The whole plant is also available for use by private importers, who are permitted to store the parcels for a period up to 12 days without extra expense, the loading of railway waggons from the silo being free within the period stated. Coal discharging plants are also to be found on the Söreng Quay and Bispebryggen in the eastern part of the port area, and at Filipstad on the west side. Beyond the above-mentioned cranes, there are also in the possession of the Port Authority two floating derricks of 5 and 40 tons lifting capacity respectively, and a 5-ton runabout crane, which are much used for loading purposes.

Granaries at Pier No. 3

Under the heading of special discharging plant may also be mentioned the sand and gravel silos with discharging cranes on the Brandskjær Pier where, one year with another, about 310,000 tons of these requisites are discharged.

In addition, many private firms have had special warehouses, with discharging and transport devices for their traffic, constructed on private property, or on areas leased to them by the Port Authority. Beyond those already mentioned, we may indicate, among others, Felleskjopet's warehouse on the Soreng Quay.

Ship Repairing and Construction Plants

Within the port area there are two shipbuilding yards, Akers Mek. Verksted (Akers Mechanical Engineering Works) and Nylands Verksted. The former has two dry-docks, measuring respectively 570-ft. by 80-ft. by 23-ft., and 260-ft. by 36-ft. by 12-ft., as well as two floating docks, which can raise vessels of 2,000 tons and 30,000 tons dead weight. Nylands Verksted has three floating docks, the largest of which measures 426-ft. 6-in. by 63-ft. 9-in. by 21-ft., with a lifting capacity of 15,000 tons dead weight. How important it is for a port to be well furnished with well-equipped workshops will easily be understood. All vessels that desire it can here have carried out repairs of every description, and the new tonnage turned out by the shipbuilding yards every year yields a considerable augmentation of our merchant marine.

Free Harbour Problems

The question of the establishment of a free harbour in Oslo has often been the subject of discussion. Thus a committee appointed by the Oslo Chamber of Commerce put forward in 1917 a proposal for the establishment of a free harbour at Lindoya and Nakholmen—two islands situated within the port area, which it was proposed to connect by a bridge with the land. The expenses of the realisation of this plan were estimated to amount to 15-20 million krones. The recommendation of the Committee was further considered by a Royal Commission who, in 1921, produced a complete elucidation of the question and proposed the establishment of a free harbour on Lindoya, Nakholmen and Heggholmen, with a bridge connection via Hovedoya to land. The expenses, it was estimated, would amount in all to approx. 30 million krones. This plan was adhered to by the Oslo Chamber of Commerce as a plan for the future, which every endeavour should be made to accomplish when economic conditions permitted, but the Chamber proposed at the same time that the possibility of establishing a free harbour in Bjorvika should be gone into further. This resulted in a scheme for a free harbour within the already existing quay area that could be realised at comparatively reasonable expense. That the plan, after all, was not realised is to be attributed to the circumstance that in it no provision was made for the allocation of space to industry, and that, apart from industrial activities, practically the same advantages could be secured without a free harbour as with one on account of the provisions contained in the Customs Act as to bonded warehouses and the storing of transit goods. Extensive provision has been made within the port area for such warehousing. In certain directions the warehouses provided in this way are regarded by the Customs Authorities as extra-territorial ground, and thus afford within themselves the same advantages as a free harbour in respect of the storing, repacking, selection and forwarding of goods. A limited productive activity can also be carried on. The advantages offered by the first schemes for a free harbour with respect to industrial areas were not afforded by the plan for a free harbour in Björviken, which, on the other hand, had the advantage that the free harbour would be very centrally situated. The previously mentioned development scheme for Björviken will make this section in still higher degree than before the centre of gravity of the port and by virtue of the large areas it will provide, the question of a free harbour here will surely come up again sooner or later.

Traffic Statistics

As mentioned before, the Port of Oslo handles about half of the aggregate imports of the country and nearly a quarter of its exports reckoned by value. From the official statistics of Norwegian trade available, it appears that the value of Norway's imports in 1937 amounted in all to 1,292.7 million krones. Of this, imports to a value of 577.5 million krones passed through Oslo. The value of exports in the same year amounted to 810.7 million kroner, and the value of exports through Oslo 155.7 million kroner.

The volume of goods in the foreign traffic has shown a steadily increasing tendency in recent years—in the case of imports, from 1,109,635 tons in 1931-32 to 1,504,111 tons in 1936-37. In the same period exports have risen from 333,511 in 1931-32 to 451,995 tons in 1936-37.

The domestic goods traffic has not previously been amenable to statistical treatment. Since the 1st of July, 1937, however, records have been kept of this traffic, which proves to be rather less than the foreign goods traffic. For the year 1st July, 1937 to 30th June, 1938, the aggregate goods traffic through the port amounted to 3,194,157 tons, of which 2,411,268 tons represented imports and 782,889 tons exports.

The number of arrivals of vessels in the overseas trade has remained fairly constant in the course of the years, varying between 2,700 and 3,100 calls. The increase in the traffic, however, appears with all desirable clarity from the net tonnage of the vessels, which in 1932 amounted to 2,534,208 tons, compared with 3,152,218 tons in 1937. The home and foreign trade together amounted in 1937 to 31,151 vessels with a net tonnage of 5,370,509 tons.

Notes of the Month

Proposed Silo at Belfast Docks.

The Belfast Harbour Commissioners have received and approved drawings for an additional silo building proposed to be erected by Messrs. Joseph Rank, Ltd., on land leased to the firm on the West side of Pollock Dock.

Terminal Opened at Havana.

A new terminal, constructed at a cost of $2,100,000 has recently been opened at Havana by the United Fruit Company. The terminal has a total wharfage frontage of 1,650-ft. and can accommodate three ships at a time. The building is 750-ft. in length and 700-ft. wide with a floor space of 360,000 sq. ft., and a complete refrigerating plant has been installed.

Greenock Harbour Improvements.

Plans for the reconstruction of Princes Pier, which is 70 years old, are to be considered in the near future by the Greenock Harbour Trust. Included in the scheme are proposals for deepening and improving the entrance basin and for deepening the Garvel Graving Dock. It is understood that the Commissioner for the Special Areas has offered a loan of £90,000 at 3% interest.

Proposed Harbours of Refuge on Great Lakes.

The survey of a number of sites on the Great Lakes of North America suitable for harbours of refuge for vessels of light draught is recommended in a recent report of the United States Divisional Engineer. Twelve of these sites are on Lake Superior, seven each on Lake Huron and Lake Michigan, three on Lake Erie and two on Lake Ontario.

Glasgow Dock Accommodation.

It has been announced in the Scottish Press that proposals will shortly be before the Clyde Navigation Trust for certain development works at the Glasgow docks. These include the equipment of the West side of the King George V. Dock with sheds and cranes, the construction of a dock or additional wharfage at Meadowside river front, and the connection of the Merklands and Meadowside wharves. It is added that no official action has yet been taken in the matter.

Mexican Harbour Works.

The wharf-viaduct which is being built at Progreso, in the Province of Yucatan, Mexico's principal henequen export port, in order to accommodate larger steamers hitherto debarred from entering because of the shallow harbour, will not be completed until August, 1940, owing to modifications in the contract. The work was to have been finished this year. The reconditioning of piers at Vera Cruz is expected to be completed during this month.

Extensions at the Port of Linhammar.

The Finnish Parliament has voted the sum of 6,000,000 marks for the extension of Linhammar port. Also, it is understood that a new railway line is projected from Rovaniemi to Linhammar in order to facilitate the export of timber, cellulose, ore, etc., by shipping the goods via Linhammar. Last year 237 vessels totalling 57,618 net, reg. tons entered the port, and it is hoped that when the entire scheme is completed, trade between Finland and the North will be considerably increased.

Sanitary Dues at Turkish Ports.

A law exempting steamers from paying extra sanitary dues in the event of their calling at a Turkish port for the purpose of taking bunker coal, has just been published. All vessels calling at the ports of Zongouldak or Heraklea with the sole object of taking a supply of bunker coal destined to cover their own requirements, and provided they abstain from all commercial operations, are exempted from paying the sanitary dues and visa tax. These vessels are, however, subject to sanitary visit in accordance with regulations in force.

New Roumanian Harbour.

On August 15th works were inaugurated by King Carol of Roumania for the construction of a new harbour at Tashaul on the Black Sea situated about 40 kilometres north of Constantza. The harbour is intended for commercial, as well as for naval purposes and will serve as a relief port to Constantza, where it is being found necessary to divert some of the shipping by reason of congestion—according to a statement in the press. The new harbour is to have an area of nearly 10,000 acres (2,594 hectares) and therefore will be very considerably larger than the harbour at Constantza, which is only about 300 acres. Construction will be carried out in three stages covering the harbour entrance moles or breakwaters, the channel leading to the interior lake on which Tashaul lies, and the dredging of the site and the erection of quays and equipment.

New German Port in the Baltic.

It is reported that the new harbour at Stolpmuende, situated 10 miles from Stolp on the German Baltic Coast, is rapidly nearing completion. The total cost of the harbour is estimated at over £2,000,000 and it is expected that the shipping basin will be ready for use in the near future.

Proposed Additional Dock Sidings at Sunderland.

A report has recently been prepared regarding the facilities and equipment at the Port of Sunderland, and suggestions have been put forward as to possible improvements. The report is receiving the attention of the Corporation Quay and Commerce Committee and instructions have been given to investigate the question of increased sidings accommodation at South Docks.

Wreck Salvage in Uruguayan Waters.

There has recently been promulgated by the Uruguayan Government of South America a Decree regulating the procedure to be observed "in regard to vessels sunk or partially sunk in waters of the Republic." The Prefecture General of Ports is given power in certain circumstances to remove or break up a wrecked vessel should the owner not have done so within a certain period.

Ludington Harbour Improvement.

The Federal Government is removing 100-ft. of the lakeward end of the South Breakwater at the entrance to Ludington Harbour on Lake Michigan, U.S.A., where last January, within three hours, two ferry steamers struck during a gale. The outer end of the North Breakwater also is being repaired. The work will widen the entrance to the harbour and will give ferry boats a better chance to weather cross gales as they head into port.

Cardiff Docks Centenary Celebrations.

At a conference held recently at Cardiff, proposals were considered for the celebration of the centenary of the West Dock, Cardiff. It was decided that the occasion should be the 20th of this month when, among other functions, it was the intention of the Chamber of Commerce to give a banquet at the City Hall. Support had been promised from a number of trading organisations and further commemorative proposals were invited.

Wireless Beacon at Longstone.

On instructions from Trinity House, the Marconi Company are about to instal automatic wireless beacons, for the safeguarding of navigation, at Longstone Lighthouse in the Farne Islands and on the Outer Gabbard Light Vessel. The installation of the Longstone Lighthouse is of historical interest as this was the home of Grace Darling, whose name is immortally linked with the saving of life at sea. The call sign of this beacon is MGD—Grace Darling's initials preceded by the distinctive letter allotted to the beacons around the British Isles.

Port Improvement at Topolobampo, Mexico.

Extensive harbour and wharfage improvements are under consideration by the Mexican Ministry of Communications at Topolobampo, in connection with surveys for the route of the extension of the Kansas City, Mexico and Orient Railway, which the Mexican Government is to construct from Ojinaga, Chihuahua State to Topolobampo. The port is to be made an important outlet for the mining and agricultural products of north-western Mexico.

Belgian Canal to be Enlarged.

Upon completion of the Albert Canal, the Belgian Government proposes to build another canal between Brussels and Charleroi. The new canal, which will be named Leopold III., is estimated to cost one thousand million Belgian francs. The work will involve the widening and deepening of the existing canal between the two cities mentioned and the construction of new locks to enable vessels of 1,350 tons to pass. When the canal is finished, the journey from Brussels to Charleroi will take only two or three days instead of twelve as at present.

Foyle Dredging Completed.

The Londonderry Port and Harbour Commissioners have announced that the dredging of the River Foyle has been completed. The work has been in progress since April, 1938, and 1½ million cubic yards (1,800,000 tons) of spoil has been removed. The scheme comprised the dredging of Lough Foyle, Rosses Bay, and the berths along the quay, and included the removal of the point of Madam's Bank. From Londonderry to the sea, the channel has been deepened to 20-ft. at L.W.O.S.T., and vessels drawing 24 to 25-ft. can now enter the port during high water at neap tides. The contractors were Messrs. The Tilbury Contracting and Dredging Company, Ltd., of Westminster, London.

*Investigation of the Outer Approach-Channels to the Port of Rangoon by means of a Tidal Model**

By OSCAR ELSDEN, M.Sc., Assoc. M. Inst. C.E.

Introduction

FOR some years past, certain areas of the approach channels to the Port of Rangoon appear to have been deteriorating to an abnormal extent, a process which would threaten the prosperity of the port if continued unrelieved and unchecked.

In 1929 the Port Commissioners invited Sir Alexander Gibb and Partners to state their views regarding a programme for future study and observation of the approach channels across the Outer Bar. Field surveys and investigations were started, and in 1931 it was decided to complete these by means of tidal model experiments.

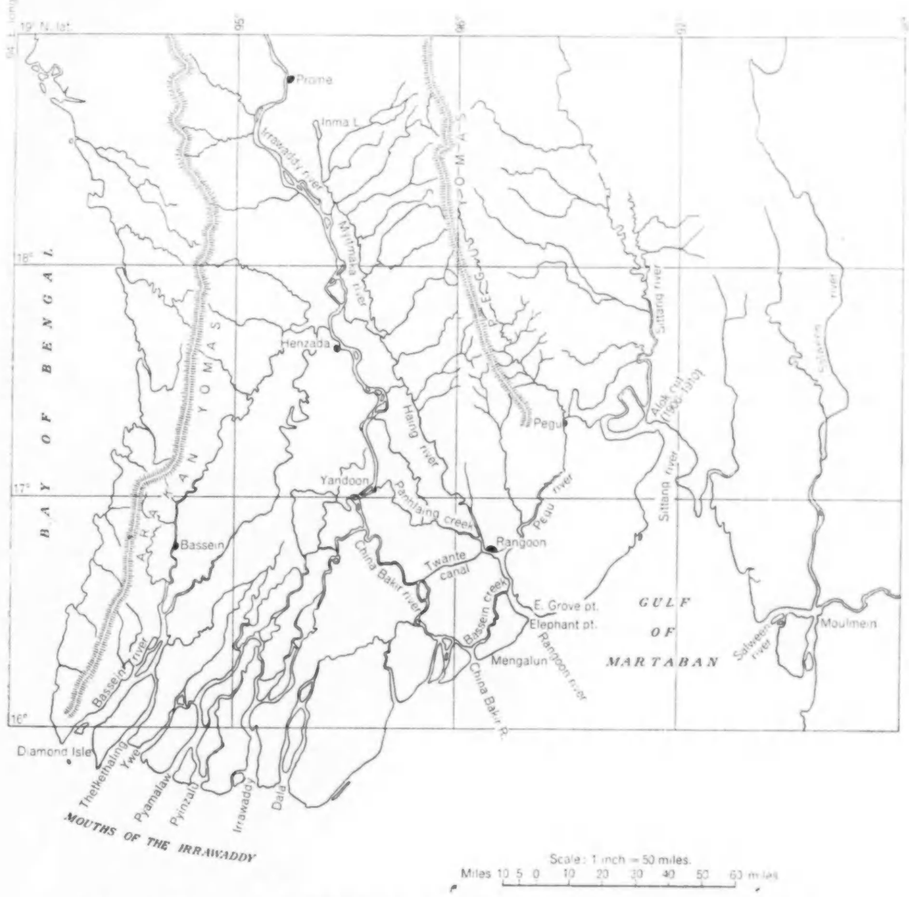


Figure 1. Map of Irrawaddy Delta, showing the position of the Rangoon River

Conditions in the Irrawaddy Delta and Rangoon Estuary

The present paper describes the tidal model experiments only, but, to provide a clear picture of the whole problem, some introductory information about the conditions of the Rangoon River is given.

Rangoon, the capital of Burma, is situated upon the left bank of the Rangoon River, 25 miles from its mouth at Elephant Point (Figure 1). The river provides deep-water connection with the sea and with the thousand or so miles of navigable waterways in the Irrawaddy delta. Railways and roads connect Rangoon with districts not served by natural waterways; the city is the commercial centre of Burma, and now handles 90% of her overseas trade.

The port is administered by a Port Commission, whose jurisdiction extends over the river from about ten miles above Rangoon to about ten miles south of Elephant Point, and also covers the entrance to the China Bakir River, another navigable mouth of the Irrawaddy (Figure 1). The upland waters of the Port of Rangoon are provided by the Irrawaddy River and by the Rangoon River.

The Irrawaddy drains an area of about 160,000 sq. miles. Owing to the monsoon it is subject to wide variations of flow, and to heavy floods in its lower reaches. Its headwaters run through districts of fairly hard geological formation, and above Mandalay, the silt content of the river is comparatively light. The lower tributaries, however, rise in softer areas, causing the silt contents to become appreciable, and as a result, the Irrawaddy has built up a delta (Figure 1), which starts near Henzada, 150 miles from its present mouths. The Bassein and Rangoon Rivers are its western and eastern extremes, and the coastline between their mouths is about 160 miles long. The area of the delta is 21,000 sq. miles, of which about one-third is drained by the Rangoon River.

The Rangoon River (in its upper reaches known as the Myitmaka), rises in the Inma Lake and flows parallel with the Irrawaddy, often at only a few miles distance. Lower down, it is known as the Hlaing, until, within a few miles of Rangoon, it becomes the Rangoon River. On its left bank are the Pegu Yomas, hills formed of soft clay and sandstone, and the numerous tributaries from these hills bring great quantities of silt into the Myitmaka-Hlaing during flood seasons.

Both the Irrawaddy and the Rangoon Rivers have several inter-connections, as the map shows; some permanent, some seasonal. During the Monsoon season there is a large transfer of water from the Irrawaddy; this transfer is, at its maximum, greater than the whole run-off from the catchment area of the Rangoon River. About four miles above Rangoon, the Rangoon River is joined by the Panhlaing creek, by which at all seasons it receives water from the Irrawaddy. The Pegu River, draining about 2,000 sq. miles of the east slopes of the Pegu Yomas, enters just below the City of Rangoon.

It is necessary to emphasise that the upland water discharge down the Rangoon River is derived from these very different sources, and that the conditions affecting the regime of the river vary greatly between the different seasons.

The formation of the Rangoon River seems to be of very recent growth, since during the 16th century the outlet of the Myitmaka-Hlaing River was via the lower part of the Pegu, which discharged further east, close to the present mouth of the Sittang. The Rangoon River in its present alignment certainly existed by the middle of the 17th century, but only became navigable in the latter part of the 18th century.

The discharges of water and of silt down the Myitmaka-Hlaing and Panhlaing Rivers were gauged in 1912-15 by the late Mr. E. C. Niven, M. Inst. C.E., then Executive Engineer to the Port, and again in 1930-33 during a hydrometric survey made by the Port Commissioners' technical officers. The figures show that during the dry season the average discharge down the Rangoon River is about 12,000 cusecs; this increases to about 170,000 cusecs during the wet season, while peak floods may bring the total to about 300,000 cusecs.

Typical results of the silt gaugings at the Kemmendine gauging station (near the junction of the Myitmaka-Hlaing with the Panhlaing), are given as follows:—

Content of Dry Silt: Grains per cubic foot of water.

		Ebb Tide	Flood Tide
Dry Season:	Neap Tides	579	672
	Spring Tides	1,050	1,052
Monsoon:	Neap Tides	256	185
	Spring Tides	290	206

The silt contents are obviously fairly high, and the other mouths of the Irrawaddy also carry much suspended matter.

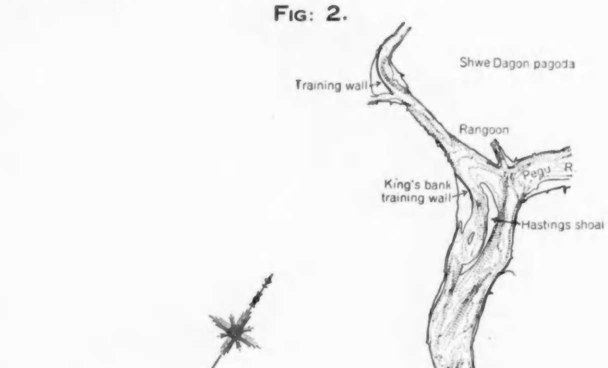
*Paper read before the Institution of Civil Engineers on 4th April, 1939, and reproduced from the Journal of the Institution by kind permission.

Port of Rangoon—continued

The Sittang River† must also be mentioned, though not directly connected with the Rangoon. Lying east of the Irrawaddy delta, it drains a total area of about 13,500 sq. miles into the head of the Gulf of Martaban. Its discharge, estimated from rain-gauge readings, is about 8,000 cusecs during the dry weather and about 150,000 cusecs during the Monsoon, when it carries a very great deal of fine silt. Its mouth is blocked with uncharted shoals, navigation is practically impossible, and there is a bore sometimes reaching a height of 6-ft. As a result, very little information is available about the river. Its importance in the present connection is due to its effect on the tides near the mouth of the Rangoon River and its production of shoals in the head of the Gulf of Martaban.

The general depth of the Gulf of Martaban is less than 20 fathoms; most of it being less than 10 fathoms deep at low water. The head of the Gulf is uncharted, but is known to be shoaling fairly rapidly, and the coastline is advancing at the rate of about three miles a century. The tidal wave flows up the gulf in approximately a north-west-south-east line, travelling at about 14 knots, and giving rise to streams which may reach a velocity of seven knots, and which, in the northern part of the Gulf, run parallel to the coastline. The converging coastlines cause a rapid increase in the range of the tidal wave as it passes eastward. The spring-tide range is 18-ft. at Elephant Point, and 22-ft. at the head of the Gulf, and the neap-tide range varies similarly. The tidal wave shows a marked diurnal variation, which may lead to a difference of as much as 4-ft. between the ranges of successive tides.

FIG: 2.



RANGOON AND THE MOUTH OF THE RANGOON RIVER.

Figure 2, which shows the Rangoon River seaward of the port, is based on the Port Commissioners' survey of 1932. It will be seen that the river meets the sea at Elephant Point, where it has a width of about three miles at high water. About six miles above this point, the channel is divided into two arms, separated by a shoal known as Middle Bank. The easternmost of these channels continues straight out to sea, maintaining a south-easterly direction. The Western Channel starts roughly parallel to the Eastern Channel, but at Elephant Point it turns, somewhat abruptly, to the south-west, and runs across a shallower area to deep water. It is this shallower area lying south-west of the mouth of the river that is known as the Outer Bar. The sands separating the seaward ends of these channels are known as the Eastern Sands.

The Eastern Channel is straight, and has at present a depth of 24-ft. at low water. But it is narrow, and subject, when the Eastern Sands are covered, to a cross-tide approaching 6 knots at spring tides. Ships must therefore use the Western Channel, which has a average ruling depth of about 19-ft. at low-water spring tides, sufficient for all ordinary traffic of the port.

Though the general topographical regime of the Rangoon River has remained unaltered for a very long period, there have been, at any rate since 1875, noteworthy changes in individual features. The main changes are:—

(1) The West Bank of the river at Elephant Point has been eroded continuously, and there has resulted a marked straightening of the six miles of Western Channel immediately above Elephant Point, and a widening of the river mouth from about two miles in 1875 to about three miles in 1932.

(2) This erosion has been accompanied by a steady widening in the Middle Bank, so that the cross-section of the Western Channel has remained very nearly unchanged.

(3) The Middle Bank has extended lengthwise in both directions, and is now practically connected with the Eastern Sands.

(4) Elephant Point, and the high-water mark along the China Bakir flats, have advanced seawards by about a mile.

(5) The Eastern Channel has steadily narrowed, and has swung slightly to the east.

In spite of these changes, the access to the port remained without serious threat until about 1910, when the Outer Bar first began to deteriorate. By 1931, when the Commissioners decided to construct a model, the ruling depth over the Outer Bar varied from 12-ft. to 15-ft. at low water (over a width of between five and seven miles). Though there is here a spring tide range of 18-ft., any further deterioration would greatly handicap shipping.

Design, Construction, and Adjustment of the Model

When model investigations were proposed there were in operation in this country tidal models of the Severn* and Mersey Estuaries, constructed by Professor A. H. Gibson, D.Sc., M. Inst. C.E., who had also constructed a model of the Humber. Further afield, Mr. John McClure, B.Sc. (Eng.), M. Inst. C.E., had constructed a model of Bombay Harbour, in which he successfully investigated problems relating to dredging, silt distribution, and the travel of sewage†; and Mr. W. C. Ash, B.Sc. (Eng.), M. Inst. C.E., had adopted model experiments to study construction and dredging problems in the Port of Vizagapatam.‡ Similar experiments with models had been made on the Continent, and in the United States of America.

Though the design of the Rangoon model owed a great deal to these experimenters, it was necessary to make certain material departures from previous practice. The channel which it was intended to study lay not in a river but in an open tideway, and was subject to the possible influence, not of one river, but of a number, forming a complex delta-system; also, conditions in these rivers were subject to important seasonal fluctuations. The foregoing description of the delta-system in which the port is situated shows the complexity of the problem of analysing the appearance and growth of the Outer Bar deposits, which might possibly be ascribed to one or more of the following causes:—

(1) Silt brought down by the Rangoon River.

(2) Silt falling into this river as a result of continual erosion of its Western Bank near Elephant Point.

(3) Silt brought down by the other mouths of the Irrawaddy and washed eastwards by tidal streams.

(4) Silt brought down by the Sittang, possibly increased in amount or altered in distribution by the sudden changes of 1906, when the Alok Cut was formed.

(5) Changes in the tidal streams due to the widening, straightening and other changes in the Rangoon River mouth.

(6) Other unknown factors.

The purpose of the tidal model was to find the cause of the growth of the Outer Bar, the extent to which it would probably develop if left unchecked, and the most economical means by which a permanent navigable channel could be maintained through it. In order that all the important factors should be represented, and all disturbing effects due to artificial boundaries

† J. M. B. Stuart, "The Sittang River and its Vagaries." Selected Engineering Paper No. 127, Inst. C.E., 1932.

* A. H. Gibson, "Construction and Operation of a Tidal Model of the Severn Estuary," H.M. Stationery Office, London, 1933.

† J. McClure, "Bombay Harbour Survey and Tidal Model," Minutes of Proceedings Inst. C.E., vol. 232 (1930-31, Part 2), p. 66.

‡ W. C. Ash and O. B. Rattenbury, "Vizagapatam Harbour," Journal Inst. C.E., vol. 2 (1935-36), p. 235. (December, 1935).

Port of Rangoon—*continued*

as far removed from the Outer Bar as possible, it was decided that the model should include as large an area around the Outer Bar as was practicable; the tidal compartments of the Rangoon, China Bakir, and Sittang Rivers; and the Bassein Creek and Twante Canal connecting the first two of these rivers. Within this area it was intended to reproduce those natural phenomena which might be considered to have any bearing upon the problem. These were:—

(1) The tidal wave in the Gulf of Martaban, including the spring-neap cycle and diurnal variation.

(2) The flows of water and of suspended silt down all rivers within the modelled area, and the littoral drift of silt into that area from the rivers which lie to the westward of it.

(3) The erosion of certain stretches of the coastlines, and the travel of silty material from this source.

(4) The accelerated settlements of silt deposits under the influence of saline sea water.

(5) The seasonal variations in the water and silt discharges, and the effect of the south-west monsoon wind.

The Governing Committee of University College, London, most generously placed a large basement at the Commissioners' disposal, and the engineers were given the fullest opportunity of co-operating with the Staffs of the Engineering, Chemical and Physical departments of the College. Two rooms were adapted, each about 40-ft. by 60-ft.; one to accommodate the model, the other being retained as workshop, storeroom and office. This accommodation permitted a suitable area to be reproduced to a scale of 9-ins. to 1 sea mile, or 1 : 8068. The vertical scale was derived from the empirical formula obtained by Professor Osborne Reynolds, which gives a relationship between the actual tide range in an estuary and the vertical scale exaggeration in its model.* From these two linear scales, the time-scale is evolved by use of another empirical formula of Professor Reynolds, which determines the ratio between the actual and model tidal periods. The remaining scales of horizontal and vertical velocity follow directly from the time-scale and the two scales of length. These principles have been adopted in this country in all tidal models as yet constructed. In the Rangoon model, the various scales were:—

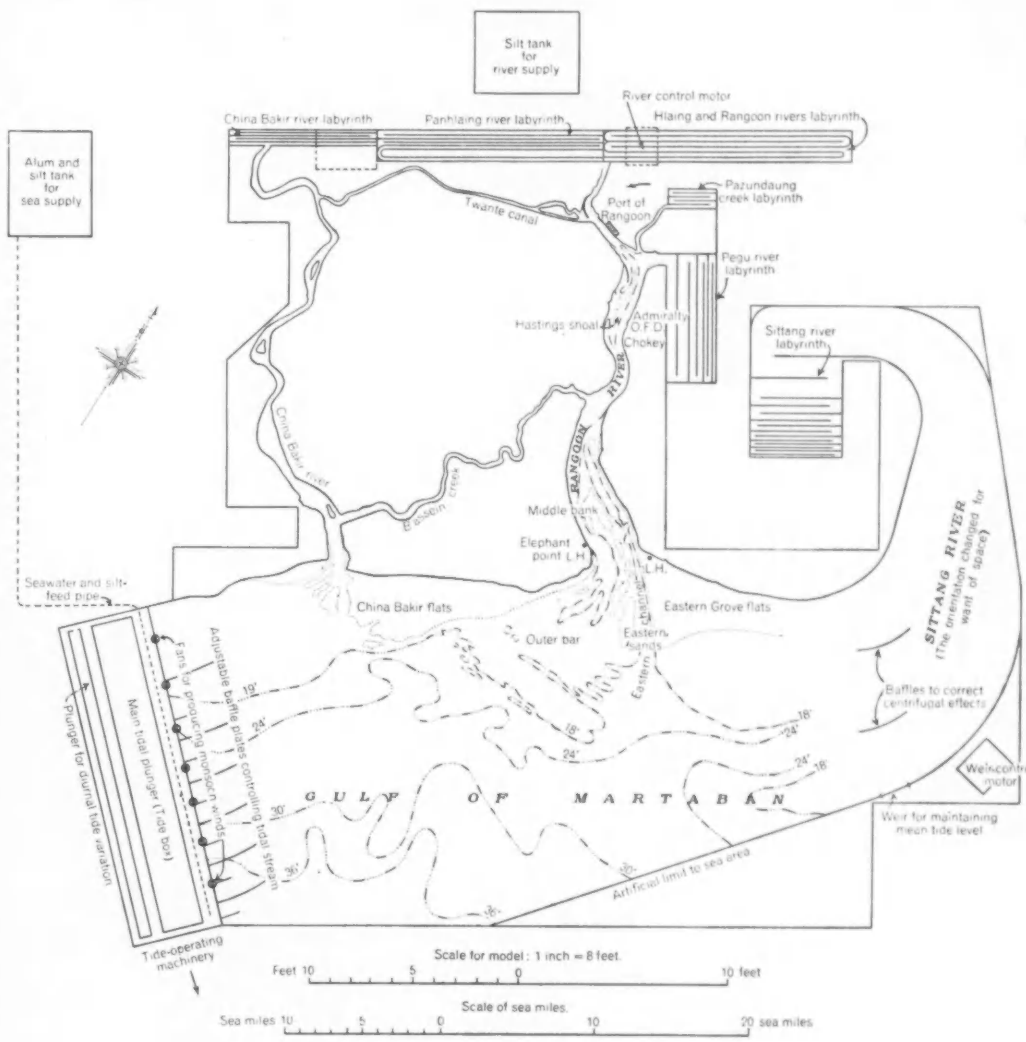
Length:	1 : 8060 horizontal and 1 : 192 vertical.
Time:	1 : 583.
Velocity:	1 : 13.85 horizontal and 3.04 : 1 vertical.
Volume:	1 : 12.500 × 10^6.
Discharge:	1 : 21.5 × 10^6.

Figure 3, is a general plan of the model as constructed. It was moulded in a special wooden tank lined with asphalt, laid on felt and expanded metal. The tank had sides 15-ins. high, and was of an irregular shape on plan. The floor and sides were supported on a substantial wooden framework, whose supports passed through the existing wooden floor of the laboratory on to solid foundations beneath: every care was taken to avoid settlement or distortion which would affect the results of working the model. Figure 4 is a typical section through the model, giving constructional details.

* Osborne Reynolds. "On the Action of Waves and Currents," Scientific Papers. Vol. 2, p. 380; also Proc. Roy. Soc. XLV (1888-89).

A chamber was formed at the "western" end of the model tank to accommodate the plungers of the tide generator, and a drain at this end enabled the whole model to be emptied. A second drain was provided at the opposite end, for the weir governing the mean tide-level. The orientation of the tide-chamber was decided after a study of the directions of actual tidal streams, and after some brief experiments with a small replica of the wooden tank intended to contain the model. The model was filled by a 2-in. diameter connection to the main. For survey, and other work, a travelling gantry was provided, which spanned the shorter dimension of the Gulf area of the model. This gantry carried a 19-ft. straight-edge used for survey, and could be moved along two rails formed of mild steel angle, permanently fixed to the wooden framing of the model. Teak datum rails, accurately levelled, were provided along each side of the Gulf end of the principal rivers. Where

FIG: 3.



PLAN OF MODEL.

these rails spanned river mouths, moveable sections were fitted.

The model tidal wave was generated by displacement plungers, operated by a mechanism similar to that previously used by Professor Gibson, part of the machinery being, in fact, obtained from one of his disused models. The tidal machinery is illustrated in Figures 5 and 6.

Two plungers were used; a main tank, to generate the half-daily tide, and a diurnal tank running at half the speed, to give the diurnal component. The sizes of these tanks were computed from the tidal volumes of the areas which were to be included in the model. Both tanks were of mild steel, welded throughout, and coated with bitumastic paint. Each was divided by transverse bulkheads into four equal watertight compartments, to facilitate trimming with iron and water ballast.

Each tank was suspended from, and driven by, an overhead rocking beam directly connected to the tide-engine, which drove the main tank by a rotating face-plate carrying an epicyclic train of gears. Upon the last wheel of this train was carried a crank-pin working in a horizontal slide-crank, which it caused to move up and down in a guide formed in a vertical pillar (see Figure 7). The slide-crank was connected by a driving rod to the rocking beam for the main tank. The epicyclic gear-

Port of Rangoon—continued

ing was arranged to alter the vertical stroke of the slide-crank, and thus of the tide tank, from its maximum to its minimum in fourteen revolutions of the face-plate, thus causing the tide generated to vary from a spring range to a neap range in the correct number of tides. The rocking beam carrying the diurnal tank was operated by a similar slide-crank and face-plate mechanism, which was driven by a chain drive from the main face-plate. Provision was also made on the diurnal face-plate for an epicyclic train which would introduce periodic changes in the diurnal variation.

The main face-plate was driven by a $2\frac{1}{2}$-horse power direct-current motor through totally enclosed double reduction worm gearing. The main gear-box, base-plate, and pedestal for the main face-plate, and the pedestal for the diurnal face-plate, were of cast iron, as also were the two face-plates themselves, and the two guide pillars. The gears were cut from mild steel and the worm drives ran on ball races. The epicyclic gears were also cut from mild steel, and ran on bronze bushes on steel pins screwed into the face-plates. The two slide-cranks were made up from structural angles, machined where necessary, and their die-blocks were of bronze. Grease lubrication was fitted to all points.

The whole machine was mounted on a substantial framework of structural steel, which was carried on rollers, permitting it to be moved along slide rails set in a concrete bed. It could thus be moved relative to the fulcrum of the main rocker, so that the range of tide could be properly adjusted. Clamp-bolts were provided to keep the engine at this setting. The main crank-pin was mounted in a slotted plate; it was possible to alter the distance of the crank-pin from the centre of the gear-wheel upon which it was mounted, and thus to adjust the spring tide-neap tide ratio. A similar adjustment was fitted to the diurnal crank-pin.

To keep the tanks balanced at all positions, two balance-weights were provided, one for each tank. Each weight was hung by a wire rope from a large grooved cast-iron cam, which was driven by roller chains connected to the appropriate tank. As the tank rose out of the water during an ebb tide, for instance, the cam increased the lever arm of the balance-weight to compensate for the loss in buoyancy of the tank, and thus kept a perfectly steady load on the main engine. The buoyancy variation amounted to about 4,500 lb., and with the 4 to 1 cam ratio provided, the weight of main tank and ballast had to be about 6,000 lb., the main balance-weight being about 1,400 lb.

The camshafts, rocking beams and other parts of the over-head gear were supported by a substantial structural steel frame carried by five stanchions and one roof-hanger. The main tank balancing gear was carried on roller bearings; plain brass bearings were used for the light loads imposed by the diurnal tank. The roller chains connecting the cams to the tanks were lubricated with thin oil supplied by wick-feeds. The grooves in the two cams for the balance-weights were lined with red fibre, to avoid undue wear in the ropes carrying the balance-weights. Bottle-screws, provided between each tank and the roller chains connecting it to its balancing cam, altered the setting of the cam, and enabled the final balance of the tanks to be very delicately adjusted. The main motor had a no-volt and overload trip, and was connected to the mains through two variable resistances, so that its speed could be accurately adjusted and maintained against the varying electrical demands of the neighbouring College laboratories.

In order to control automatically the seasonal variations in the various discharges of silt and fresh water, and in the mean sea level, a timing gear was provided on the main engine. The device consisted of a reduction gear rotating a shaft once for every 704 tides, or one "model-year." This shaft carried two cams, each of which closed an electric switch for half a revolution of the shaft or for the model equivalent of six months, and the two cams were set so that when the one switch was closed the other was open. The first cam closed an electric circuit and caused a number of small motors to bring the model under

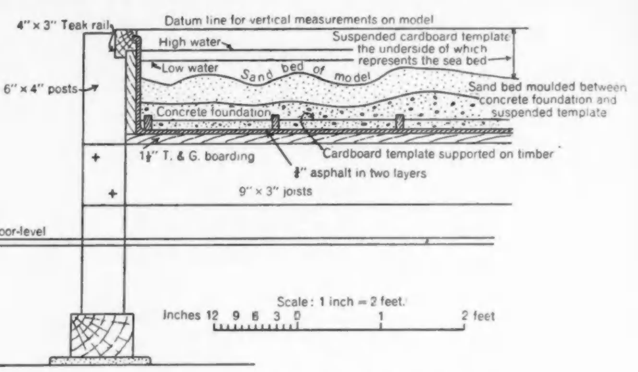


Figure 4. Typical Section through Model

monsoon conditions for six "model-months." At the end of this period, the "monsoon circuit" was broken, and the second cam closed the "dry-weather circuit," bringing all the model-rivers, etc., to dry-weather positions. The seasonal variations were thus rendered independent of manual control, and the model could be left unattended when running at nights without affecting the experiments.

Six rivers were included in the model. Each had a separate measuring vessel with two compartments and a measuring orifice in the bottom of each compartment, one to supply the average dry-weather flow, the two together to discharge the average monsoon flow down the river. Each river-measuring vessel was fitted with a gauge-glass and scale, the scales being marked after calibration in the Hydraulics laboratory of the College. The discharges of the model-rivers were based on the field gaugings, to which reference has been made, or on calculations from rainfall. In the case of the Sittang, only one-half of the calculated discharge was supplied to the model, for it was considered that only half the actual river could be said to flow into the modelled area. All the rivers received their water from a 250-gallon tank to the main by a ball-valve. Two separate pipe-lines delivered water to each measuring vessel. The first was continuously running, and was adjusted by a screw-valve to deliver the correct dry-weather flow. The second pipeline was similarly adjusted, so that its discharge brought the flow of the model river up to the mean monsoon rate, and was opened by the timing gear during "monsoon seasons." The proper periods of monsoon and dry-weather flow were thus obtained. As actually arranged, the monsoon pipelines for all six rivers were controlled by one direct-current motor of 1/20 horse power.

Silt was discharged into the rivers at rates determined from the field observations. A hopper-and-belt feed carried the silt into the river supply tank, where the silt-laden water was kept agitated by a propeller. The rate of silt fed to the tank was varied between monsoon and dry seasons by means of the timing gear on the main engine, which increased the speed of the belt-feed during the monsoon.

The littoral movement of silt from the more western mouths of the Irrawaddy was reproduced in the model by an additional feed of silty water. The rate at which this "tidal" silt was introduced again followed from field observations made for that purpose by the Port Commissioners' staff, who took extensive series of silt gaugings in the real Gulf of Martaban on flood and ebb tides, and determined the silt contents at a number of standard stations under all tidal and seasonal conditions. From the difference between flood-tide and ebb-tide silt contents it was possible to compute the rate at which silt was entering the modelled area from the westward, and thus to decide the amount of silt which should be fed into the model from this source during the course of each model tide.

This tidal silt was supplied to the model from a tank similar to that used for the supply of the model-rivers. In this tank the silt was stirred up in water carried along a perforated trough spanning the model immediately in front of the main tide-plunger. The spacing of the perforations was varied, so that the greater part of the silt was discharged fairly close in-shore, and decreasing amounts further seaward; the field observations showed that there was such a turbidity gradient. Checks made during the operation of the model at places in the model Gulf corresponding with the actual gauging stations gave silt-distribution re-

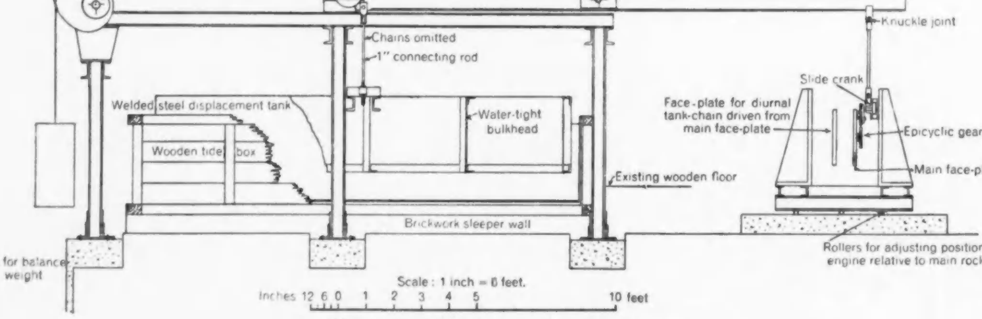


Figure 5. Tide Generating Machinery

Port of Rangoon—continued

sults which agreed well with those recorded in the real Gulf.

It was essential that the silt in the model should settle at the proper scale-rate, and that the model should allow for the sudden acceleration of settlement which occurs in nature when a stream of dirty water flows into the sea. Following the method adopted by Professor A. H. Gibson in the River Severn model, a coagulant solution was used for this purpose. "Actual-settlement rates" were determined by making up suspensions of Rangoon silt in Rangoon sea-water in standard proportions, and noting the times necessary for these suspensions to settle. These tests were carried out in Rangoon by the Port Commissioners' Engineers.

Similar tests were repeated in the model laboratory, using similar suspensions of commercial clays in coagulant solutions and a series of "model-settlement rates" was found. The summary of scales on page 8 shows that vertical velocity in the model must be about three times that in nature; thus the "model-settlement rate" should, correctly, be three times the "actual-settlement rate."

In the latter series of tests, two commercial clays were selected, of which uniform supplies could be obtained in suitably finely divided form. Their settlement rates were tried in coagulants of different forms and concentrations to find the most suitable coagulant for use.

The proper settlement was obtained by introducing potassium-alum to the model-sea in sufficient quantity to maintain a density of 1.0025. The alum was dissolved in perforated trays suspended in the tank which supplied the tidal silt to the Gulf.

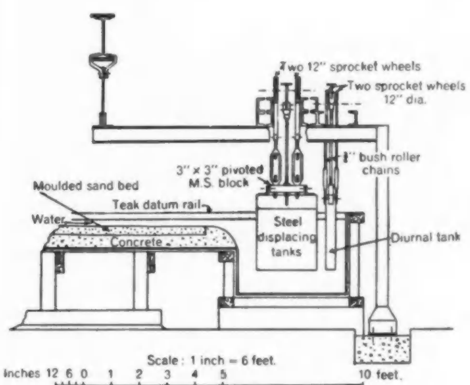


Fig. 6. Section showing Tide Generating Machinery

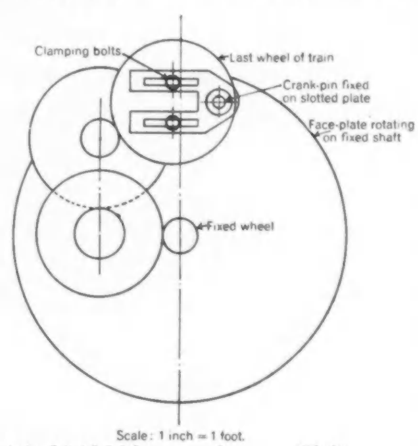


Fig. 7. Diagram of Epicyclic Train

In order to keep the model-sea at its proper mean level, a weir was fitted at the position shown in Figure 3. The weir was formed of a vertically-sliding brass plate, and had a crest 18-ins. long. It was arranged so that the crest of high water just spilled over into the drain provided for the purpose, and could be adjusted so that the dry-weather mean level was properly maintained against the discharge of water down the model-rivers. When these discharges increased during the model-monsoon, the weir was slightly lowered by means of a 1/20 horse power direct-current motor; this was controlled by the timing gear on the main engine, and also raised the weir when the model-rivers returned to their dry-weather discharges. The lever arms from which the weir was suspended could be adjusted, and it was found possible to maintain the model sea-levels at values closely corresponding to actual figures.

The Elephant Point tide-gauge was chosen as the measuring point for mean sea-level, which at this point had been established in the relation to the datum for soundings in the Gulf of Martaban. The slight seasonal variation in mean tide-level at this gauge, due to the Rangoon River flow*, was reproduced in the model.

The south-west monsoon winds caused considerable sea disturbance in the Gulf. The appropriate waves were produced in the model by a battery of seven fans, connected to the seasonal control-gear which operated them for the proper periods. The fans were adjusted to create waves travelling in the proper direction, and, on the advice of Professor Gibson, the strength of wind produced by the fans was adjusted until the model-waves had the correct height from crest to trough, a factor considered to be of more importance in this case than length or speed.

For moulding, and for subsequent survey-work, the datum rail was marked off into a system of permanent section-lines; over the Outer Bar area these were a quarter of a mile apart, this interval being increased in the less important areas. This system of section-lines was referred to the Shwe Dagon pagoda at Rangoon and to Eastern Grove lighthouse at the Rangoon River mouth, two landmarks whose latitude and longitude were known, and which were represented in the model by permanent steel pegs. The section-lines were plotted on all actual charts.

Much of the model was permanently moulded in concrete, in order to save time in the frequent remouldings, to standard conditions. The China Bakir River, Bassein Creek, and Twante Canal were completely moulded in this manner, as were the more permanent features of the Rangoon River. Space was left in the Rangoon River for the introduction of softer materials with which to reproduce past erosion of its banks, and that which might be estimated to occur in the future. The whole bed of the model, as moulded in concrete, was kept below the levels shown on the charts, and there was a final layer of sand, 3-ins., or about 50 scale ft., thick. Round the mouth of the Rangoon River the thickness of this sand bed was increased to 100 scale ft., in order to give room for considerable scour which normally occurred, and which might be increased by the construction of hypothetical engineering works. The lands between the various rivers consist mainly of low-lying paddy fields; their level is generally below that of high water, and they are protected from flooding by bunds, though heavy flooding does occur in the monsoon season. These features were reproduced in the model, in case a study of the effects of abnormally high tides, or of flooding, should be required.

The concrete moulding was done by means of cardboard templets permanently fixed to the asphalt floor of the model tank. The spaces between these templets were packed with coke-breeze with about 2-ins. of concrete on top, the surface of the concrete being brought accurately up to level by a rendering of 1 : 4 cement mortar. More intricate parts of Rangoon River were moulded in paraffin wax.

For the moulding of the overlying layer of sand, cardboard templets were cut to the profiles shown on the natural charts. These were suspended from above the model by a wooden frame (see Figure 4). The sand spread over the model was made fairly damp, and was accurately moulded to these profiles by hand and with the aid of trowels. The amount of sand in the model was about 14 tons, and the complete moulding required about 10 days' continuous work.

The converging coastlines of the Gulf of Martaban cause a marked increase in the range of the tidal wave as it travels eastward; this funnel effect was reproduced in the model by forming the seaward boundary, as shown in Figure 3. The portion of the tank intended to contain the model gulf was made rectangular, and the additional internal boundary was put in after the whole tank had been asphalted; provision was also made to alter its alignment should it fail to produce the required increase in the tidal ranges.

Owing to the flatness of the deltaic plains, the rivers in the modelled area are tidal for very considerable lengths, and it was impossible to mould geographically the whole of their tidal compartments. Beyond the limits shown in Fig. 3, Plate 1, these were accordingly reproduced by labryinthine passages, arranged to give the correct tidal volumes within manageable compass. The partitions forming each labyrinth were of sheet-zinc, and were arranged to give approximately the same convergence as the banks of the river which they represented. The beds of these labyrinths were made up with sand to give the correct bed-slopes. Provision was made in the case of the Sittang labyrinth to reproduce the effects of the Alok Cut.

(To be continued)

Sunderland Port Improvement.

Owing to the increase in coal shipments, the Wear Commissioners are undertaking repairs to two old staiths at the South Docks. The repairs at No. 21 staith are well in hand and it has now been decided to spend a further £2,500 in putting No. 6 staith into good order. It is expected that the work on both staiths will be completed before the winter. Good progress is being made with the scheme for straightening and deepening the entrance to the harbour. Dredging was started last summer, and the scheme is scheduled to be completed in five years. At present the channel is slightly curved, but eventually there will be a straight channel between the inner and outer piers with a depth of 23-ft. at L.W.O.S.T., or 37-ft. 6-in. at high water, an additional depth of from 3 to 5-ft.

*** Tide Tables of the Indian Ocean. From Admiralty Tide Tables, 1938, Tidal Predictions. Part 1, Section B.—Foreign Waters (The World, except British Islands and North and West Coasts of Europe). Published by His Majesty's Stationery Office for the Hydrographic Department, Admiralty.**

River Nene Improvement Works

The improvements made in the lower portion of the River Nene, and the rectification of the navigable channel leading to the ports of Wisbech and Peterborough, are set out in a booklet issued in connection with the recent annual inspection by the River Nene Catchment Board, who have been carrying out the work for several years past with the assistance of a grant from the Ministry of Agriculture and Fisheries.

The following description of operations in the vicinity of Wisbech is extracted from the booklet.

Works at Wisbech

The works at Wisbech consist of sheet piling a length of about two miles of river from Wisbech Bridge upstream, as a preliminary to the removal of extensive shoals in the existing channel. The piles are made of reinforced concrete and driven in the form of an inverted "V," as shown on the section. The sheet piles are 23-ft. long, and 24-ins. by 10-ins. in section driven at a rake of 1 in 5; the king piles, which are at 6-ft. intervals, are 27-ft. long and 12-ins. by 12-ins. in section driven at a rake of 1 in 3. The main reinforcement in the sheet piles consists of six 1-in. diameter bars and in the king piles four 13-16-in. bars. All the piles are cast with a ¾-in. pipe along the vertical axis, and when driving is in progress water is pumped through the plies under pressure. The water saturates the ground beneath the pile through three openings in the pile shoes, and this is of considerable assistance both in driving the piles and in reducing vibration.

The concrete for the piles is mixed in the proportions of 7 cwt. of rapid-hardening cement to ½ cu. yd. of sand and 1 cu. yd. of aggregate.

The piles are cast in a single layer in timber moulds. The sheet piles are cast in 18 beds, each containing seven piles; there are three beds for king piles, each containing ten piles. Alongside the pile beds is a broad gauge track for the travelling cranes which lift and stack the piles, and in the middle of this track is a narrow gauge track on which the skips containing the concrete travel from the mixer to the pile beds. On the side of the track, away from the pile beds, is the stacking ground, and behind this is the site where the reinforcement cages are assembled and the stock of reinforcing bars and bending machine.

A daily output of piles is 25 sheet piles and 10 king piles, which allows a four-day maturity period before the piles are lifted. A further period of about three to four weeks passes before they are driven.

From the pile yard the piles are transported by lorry to the pile frames where they are unloaded and pitched by the crane.

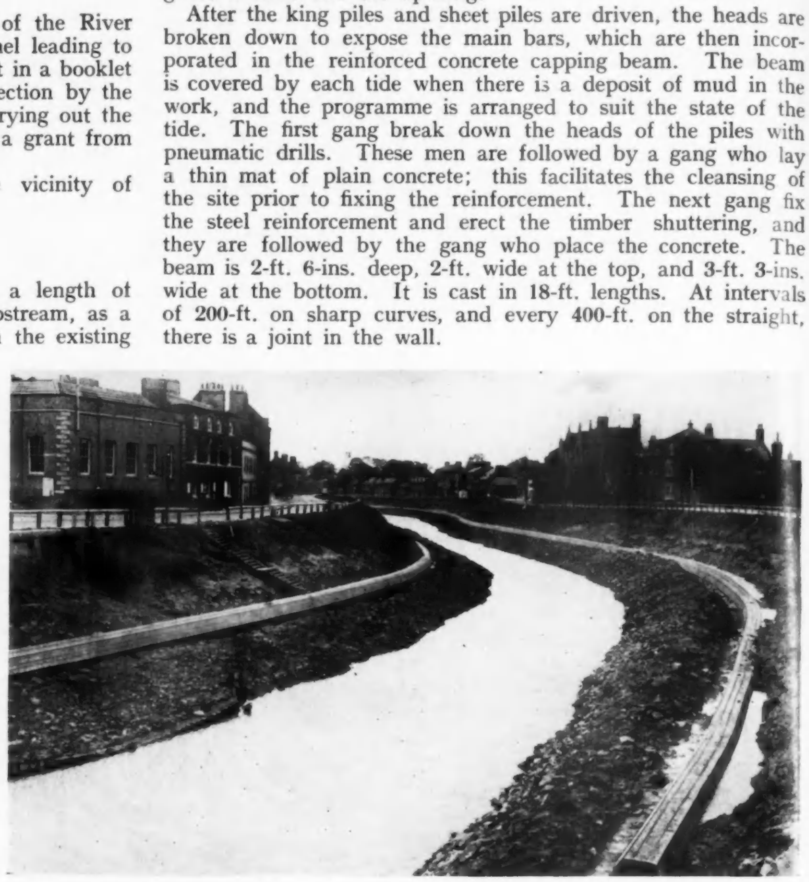
There are over 13,300 piles to be driven, of which about 3,300 are king piles. Owing to the great distance between the edge of the road along the river bank and the line of the new work, pile frames of a special design were required. The Contractors designed frames which have fixed leaders inclined at the appropriate batters to which the king piles and sheet piles are to be driven.

The frames are of lattice construction, and are grouped in pairs to work about 60-ft. apart. A steam crane and pump for the jetting is provided for each pair of frames. The frames are carried on a rail and cill at the top of the bank and a rail on timbers near the level of the tops of the piles.

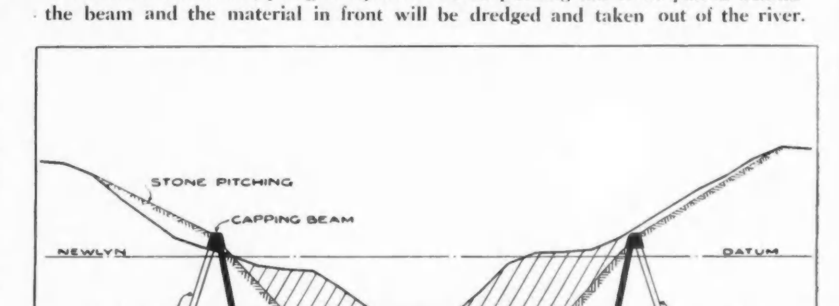
Drop hammers are used for driving the piles and weigh two tons for the sheet piles and 30 cwt. for the king piles. The jetting is used in conjunction with the hammer until the pile has been driven to a depth of 18-ins. above its final position, after which the hammer only is used with a drop of 15-ins. An average set for the piles is about 1½-ins. for the last 10 blows.

It is necessary that the sheet piles should be continuous, in view of the subsoil of sand and silt, and it has been found that old piles and other obstructions below the ground tend to force some of the piles apart. All the sheet piles are cast with a "V"-shaped groove each side, extending about 11-ft. from the top of the pile; if piles are not close when driven, the grooves between the piles are cleansed with compressed air, and a long bag of calico filled with cement grout is filled into the opening.

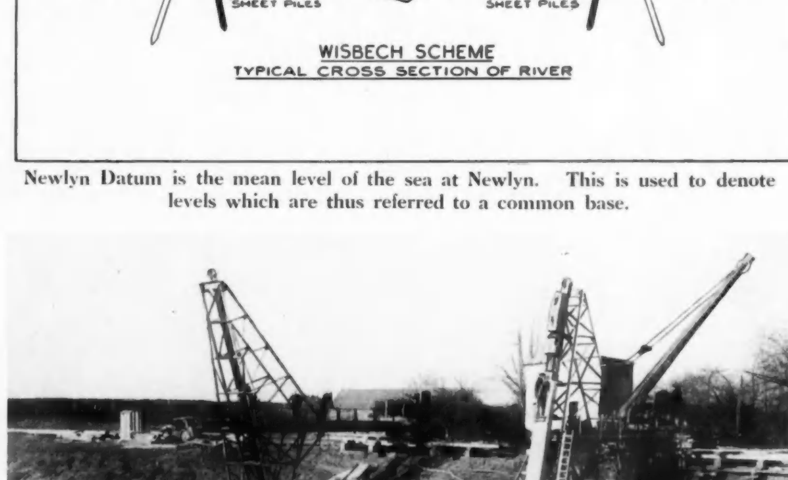
After the king piles and sheet piles are driven, the heads are broken down to expose the main bars, which are then incorporated in the reinforced concrete capping beam. The beam is covered by each tide when there is a deposit of mud in the work, and the programme is arranged to suit the state of the tide. The first gang break down the heads of the piles with pneumatic drills. These men are followed by a gang who lay a thin mat of plain concrete; this facilitates the cleansing of the site prior to fixing the reinforcement. The next gang fix the steel reinforcement and erect the timber shuttering, and they are followed by the gang who place the concrete. The beam is 2-ft. 6-ins. deep, 2-ft. wide at the top, and 3-ft. 3-ins. wide at the bottom. It is cast in 18-ft. lengths. At intervals of 200-ft. on sharp curves, and every 400-ft. on the straight, there is a joint in the wall.



Wisbech at low water; piling completed. Stone pitching has to be placed behind the beam and the material in front will be dredged and taken out of the river.



Newlyn Datum is the mean level of the sea at Newlyn. This is used to denote levels which are thus referred to a common base.



Pile frames at Wisbech. The frame on the left is for driving king piles and a sheet pile is in position ready for driving at the other frame

River Nene Improvement Works—continued

The Engineer of the Catchment Board is Mr. Harold W. Clark, and the Contractors for the works described are Messrs. W. and C. French, Ltd., Buckhurst Hill, Essex.

The following additional note on the present position has been courteously furnished by Mr. Clark.

It is anticipated that the works of reinforced concrete sheet piling along the banks of the river for a length of two miles above Wisbech Bridge, will be completed during the present year. The dredging of the river channel along this length, which forms part of the scheme, will shortly be put in hand.

At the moment, there are shoals of stone in the river bed above Wisbech Bridge, which restrict the channel, and the piling works are a preliminary to the dredging of the river.

Although the river works are not yet complete, sea-going vessels are making regular journeys to Peterborough. When the works at Wisbech are completed and the new road bridge is constructed at Guyhirne, the facilities for both drainage and navigation will be improved. At the moment, the combination of the shoals at Wisbech with the very low bridge at Guyhirne, tends to cause delay when large vessels are making journeys on the river.

In the upper reaches of the River Nene there is now a regular service of barges from the Midlands and London to points near Northampton and Wellingborough. A number of the new locks are now in use, and rapid progress is being made on the reconstruction of the remainder.

*Port Administration**

By J. H. HANNAY-THOMPSON, Ph.D., B.Sc., B.Com., M.Inst.T.

All commercial ports fulfil the same economic functions, but there is no uniformity in their administration and ownership, though throughout the world the routine management is similar, and is in the hands of whole-time officials. The ports fall into five main groups. The differences between them are brought out in the varying powers of the officials and in the constitution of the authority to whom they are responsible. The different forms of administration have arisen and exist through endeavours to assist the head official to carry out his duties in an efficient and impartial way. The efficiency of a port is also effected by the competence and freedom from bias of all those persons who, by vote or otherwise, have the power of decision in harbour matters. The inherent weaknesses of the different systems become most apparent when the administration is bad, and those who control them do not act in the public interest, but for their own personal ends.

Ports, irrespective of their statutory or other obligations, are usually actuated by ordinary commercial principles. Where their hinterlands overlap, keen competition exists between them, and examples of uneconomic rate-cutting are frequent, particularly where the ports are completely independent, as in Great Britain and the United States, where examples of administration from all points of view are found. The total volume of the seaborne trade of a country passing through the ports is outside their immediate control. The provision of new and up-to-date facilities will develop a trade, but it will not originate or foster one, the possibilities of which are not in existence in the first place.

Administration by Statutory Trust

The statutory port trust is the typical British form of ownership. The great advantage of this system is that the actual control is in the hands of those members who, through representing commerce, have personal knowledge of the facilities required and of any defects in management. As they have to pay for the services rendered in the form of rates and dues on vessels and goods, a strong check is kept upon extravagance, though a port may provide special facilities to attract the trade of a rival.

The chief disadvantage is the extent to which its finances are dependent upon the fluctuating traffic of the port and the difficulties which it may experience during prolonged periods of trade depression. Interest and redemption charges have always to be paid on the capital debt, while the property must be maintained in proper condition regardless of the number of ships entering the port. Thus, in times of bad trade, a port trust is rarely able to assist trades by reducing its charges.

Most of the British port trusts were constituted with a large number of members in order to safeguard all the interests connected with the port. Where the total membership of the board is small, say fifteen members, the percentage of attendance is in the region of 80%, but, except for London and Liverpool, it becomes progressively worse as the size of the board increases. The average attendance for a board of over twenty-five members is about 60%. Approximately ten members of a board, irrespective of its size, have an attendance at meetings of 75% and over, and these members appear to initiate most of the policy, while the others form a judgment thereon. With a 60% attendance, one-third of the board is able to dominate the policy of the board. When the chairmen of committees and officials work in harmony and have the confidence of the board, the system leaves nothing to be desired, but when there is conflict of opinion between the constituent members of the board they tend to join in groups or factions who vote from personal motives and on instructions from outside bodies or from opinions which have been somewhat hastily formed, to the detriment of the port.

The port trusts in the British Colonies and Dominions have similar constitutions, but upon the whole the number of trustees is smaller, usually between fifteen and twenty.

National Administration

The next most important system is where the harbours are administered by the State, as in France. The financial position of all ports is guaranteed by the Government, and they are independent of trade fluctuations for their financial stability. The Minister of Public Works lays down the general policy for all ports and places the local administration in the hands of government port directors who are in complete control and are responsible for all capital works which require government money. The routine management and operation of the ports is, however, placed in the hands of the Chamber of Commerce, which employs the port director as their general manager. He thus really works for two masters, and acts as the co-ordinating link between the State and the local authority. He is assisted by a consultative committee of usually nine members, who are appointed by decree by the Government.

In France harbour expenditure forms a part of the national budget in the same way as the fighting and other services. Port policy is subject to political influence and the exigencies of national finance, and a complaint frequently made is that after the requirements of the defence and ordinary services have been met by the Government, little money is left for port development.

Similar systems of port administration are found in Italy, Latin America, and some other countries. In Russia, the harbours are controlled by the Narkomvod (People's Commissariat of Water Transport), which controls all means of river and sea transport, including harbours. Lenin laid down: "In water transport an iron military discipline must be created." This has been done, and the whole management of the harbours placed in the hands of officials who are responsible to the Commissar of Narkomvod. The detailed organisation of the harbours is similar to that in other national harbours, except that particular attention is given to the training of qualified workers by state technical schools, while the arrangements for feeding and housing of workers are carried out by sub-departments of the port.

In state harbours, government officials are in a position to insist upon impartial treatment. The ports of the country are worked as parts of one unit. The Government can prevent the construction of redundant facilities and, where two ports wish to provide facilities for a new trade, can ensure that they will be provided at the port which can handle the trade more efficiently. The chief criticism levied against the national system is its lack of flexibility, and the absence of close contact between officials and commercial interests. The latter are only able to advise without having the power of active decision.

I have often been told that the grip of the Central Government upon local officials is unduly strong. These officials are forced to submit many matters to their superior officers which in trust-owned ports would be settled on the spot. The reviewing of such questions places upon the officials of the Central Government a larger amount of work than they are able to get through, and it is quite common for delays up to as much as three years to be experienced. Another serious complaint against the system is the complete dependence of the port for its success upon the ability and probity of the officials concerned. It is hard for those outside the Government service to get changes made where they deem them necessary, and before any action can be taken, the abuses of which complaint is made must be grave.

Municipal Administration

Municipal administration is the standard type which is found in operation in many Continental European ports and in the United States. The general method is very similar to that of the statutory trust. The differences arise through the difference in the financial powers and constitution of the controlling bodies. A municipal port has the financial backing of the city behind it. Capital works are thus frequently provided out of the city funds, while working deficiencies can be made up out of the local rates. The city councils are primarily elected, not upon the basis of business qualifications or competence, but upon the ordinary party principles. For the members to be trained in matters connected with shipping is, therefore, generally the exception to the rule, and they have to familiarise themselves

* Abridged text of Paper read before the Scottish Section of the Institute of Transport, on March 20th, 1939. Reproduced by permission from the Institute Journal.

Port Administration—continued

with harbour affairs whilst carrying out their duties. The great weakness of the system is due to this prominence of party politics and to the instability which sudden changes of policy bring into the service.

Although the large European municipal ports, such as Antwerp and Rotterdam, have been administered as municipal trading concerns, the interests of trade have usually been placed before those of municipal electors. This has not always happened in cities in which the port is of relatively small importance where the port has often been neglected, or exploited as a means of revenue, or vote-catching. As a rule, where the number of persons delegated by the municipality to supervise the administration of the port has been of medium size, the administration has been most efficient, but where it has been placed in the hands of two or three persons appointed by the municipality, as in Canada and the United States, grave abuses have frequently arisen.

Another great disadvantage lies in the difficulty which is experienced by traders in getting their wishes considered in the event of their being at variance with the harbour authority or its officials. The officials themselves, lacking the strength of the Central Government behind them, are less able to maintain an independent attitude than in the state-owned harbours.

Railway Administration

When a railway company controls ports, the railway portions of the undertaking are of great magnitude when compared with the ports which they administer, and the ports are often regarded as a side-line to railway transport and as feeders to the railway system.

Great advantages and economies are experienced where one railway company owns a number of ports. Where a port specialises in mineral traffic, railway administration is very efficient, particularly in regard to the ease of handling traffic. The railway companies, within their own systems, are able to avoid duplication of facilities, or to close redundant harbours. They are able to work all ports as one unit, with consequent economies in floating plant and personnel. Where harbour specialists are employed, they attract personnel of greater ability for the higher executive positions than could be obtained by an individual port, though subordinate officials upon the spot are usually of lower ability and less responsible than those of independent harbours. Easy communication and internal telephone systems make questions of distance and situation of personnel of little importance to the company.

On the other hand, especially in South Africa, this particular form of administration tends to a narrow outlook, with a lack of complete appreciation of the part which a harbour has to play in developing the commercial prosperity of a district. The railway management is apt to concentrate only on such trades as will prove remunerative to the whole railway undertaking. In railway administration, many of the disadvantages of a state system are apparent, in particular the lack of contact between those directly responsible for the laying down of policy and the individual local interests. Competition between railway interests, as exists in Great Britain, has led not only to the provision of harbours almost national in their extent—where a local trust could not have financed an undertaking of such magnitude—but has also shown examples of the provision of redundant facilities which have undoubtedly caused over-capitalisation of the harbours in this country.

The rigidity of a railway system is also responsible for much delay and inefficiency in detail, particularly when men who have not devoted time to the study of ports are called upon to make decisions which require a breadth of experience which can only be acquired by intensive training in port problems.

Company Ownership

The history of the financial difficulties experienced by the private dock companies in Great Britain proves that this form of administration is not suitable for ports of a large size which conduct a diverse trade.

General Review

It seems to me that as a general rule, except for completely new industries and the natural growth of established trades, new traffic is only developed in a harbour at the expense of other harbours with which it competes. In consequence of this redundancy and the complete lack of co-operation between ports in planning new works with reference to the existing and probable total trade of these countries, the ports as a whole carry an extremely heavy burden of capital debt; interest and sinking fund charges amount in some cases to as much as 50% of the annual expenditure, which has the effect of maintaining the rates at a relatively high level. When the overseas trade figures for Great Britain before the war are compared with those of the present day, the increase in the net registered tonnage of vessels entering British ports is only 3% greater in 1936 than it was in 1913, in spite of the phenomenal amount of new construction which has been undertaken in ports during the period.

When all the varying systems of port administration are considered as a whole, it appears that the principal disadvantages peculiar to ports, when compared with commercial and industrial enterprises of similar magnitude, are the delays which are often experienced in reaching major decisions and obtaining ultimate sanction for major works, together with the existence in most countries of uneconomic competition leading to the construction of redundant facilities of very high cost.

The administrative organisation outlined below is suggested with a view to creating a form of administration which would be flexible and more sensitive to local needs and conditions than those at present in existence. I think it is better to base the constitution of the administration upon the presumption of the honesty and competence of the officials and those serving upon the administrative bodies with a general power of safeguard, rather than to stress safeguards against possible undesirable circumstances.

Requirements of the Ideal Form of Administration

There are certain principles which, I think, must be the basis of all port administration, in particular where the country has a large and diverse trade. In every country there should be a central authority, nation-wide in its scope, which would have power to lay down the guiding principles of the policy governing the individual harbours. The administration should lie in the hands of some form of public or national organisation whose interests and decisions should be completely impartial. The local administration of all ports should be conducted upon similar lines, and powers should be given to the central authority to prevent uneconomic competition. Each port should have sufficient financial resources at its command to enable it to finance its cost of construction and any subsequent additions. The administrative authority must be in a position to make decisions quickly to keep in close touch with trade and its requirements, while at the same time it must be a responsible body. Those who direct the administration must have a highly specialised knowledge to enable them to solve the intricate technical and financial problems which port administration presents, such as can only be obtained through a period of training, or, uninfluenced by selfish motives, they must be in a position to pass a reasoned judgment upon such alternative propositions as may be placed before them by experts in the various fields covered by port administration. A competent staff of highly-trained officials is required to carry out the routine work of a port. They must devote their whole time to the service of the ports and the consideration of their problems.

Proposed New Administrative Organisation

There should be a centralised controlling body in each country in the form of a central trust with national scope, which would treat all ports as part of a whole. The individual ports should be controlled in local matters by commissioners and all upon similar lines.

Central Organisation—Functions:

The central trust should have power to lay down the basic principles of port administration for the country and to decide all major issues of policy for each port and co-ordinate the efforts of all. Its functions should be judicial rather than administrative. All the financial powers and resources of the ports should be vested in it, and all port stock, debts or loans should be combined in a central capital fund.

This central trust should take over all governmental functions, such as those at present carried out by the British Parliament and the French State departments. Its decisions should be final. It should be administered upon the same principles as those at present governing the trust ports, and it should take over the property in the assets of all ports and assume all their liabilities, by way of invested capital or loan debt. It should also control all surplus revenues or deficiencies of individual ports. In the countries in which there is at present no national form of ownership, it would be necessary for this central trust to acquire compulsorily all ports from the authorities at present owning them, and to give adequate compensation in the case of ports which were run for profit. No such compensation would be necessary in the case of trust-owned ports, which would be relieved of their existing debts in return for the acquisition of trusteeship over their assets. In the case of countries with a national system of administration, the State would have to receive a capital sum in return for the assets, and it would have to surrender control of the revenue and expenditure, which would be placed in the hands of local commissions under the control of the central trust. In such countries and newly-developed or colonial countries, it might be necessary for the State to provide part of the capital for the central trust, or guarantee the interest and sinking fund.

The central trust, through its control over the central funds, should exercise a judicial faculty in deciding the rival claims of the different ports for new facilities or trades. It should be able to see that such trades were routed in the most economical

Port Administration—continued

manner, and further, that proposals for such new facilities as were required showed sufficient breadth of vision to be adequate for the anticipated requirements of the port for a considerable period, but, at the same time, were not in excess of those requirements, viewing the trade of the country as a whole.

It should also be in a postion to construct new harbour works anywhere upon the country's coastline, irrespective of local financial backing, and it should prevent the construction of obviously redundant facilities where ports were competing for the same trades. It should also have powers to require a port to improve its facilities to meet increasing trade, or in the event of their becoming obsolescent, or to close ports or portions of them which were out of date and working at a loss, when the trade could be handled more expeditiously elsewhere.

The central trust should have the power to lay down the basis upon which the rates levied in the individual ports should be fixed, but should not fix the port's individual rates or concern itself with details of local administration. (The central trust could, however, in certain circumstances, be constituted a court of appeal, not only upon questions of rates but also facilities, etc.).

The central trust should be composed of men who would review all questions in a judicial capacity without favouring or endeavouring to obtain undue favours for any section of industry or the interests they represent. It would be necessary to attract men of high calibre and extremely wide experience, who would carry out their duties from a national viewpoint.

The Central Trust—Constitution:

It is proposed that the central trust should be composed of about twenty-five members who would represent the various activities which have an interest in ports. The members should serve for periods of five years, and one-fifth of the members in rotation should retire annually and be eligible for re-election. One impartial representative of each category should be sufficient. Trade and shipping representation should balance port official representation with a certain number of Government representatives or nominees. The representatives of a trade or other interest upon the local commissions would elect the corresponding representative upon the central trust. Government representatives would be appointed by the department concerned, while legal or other experts could be co-opted by the members already elected or appointed to represent the other port interests. All members of the central trust should receive a high remuneration for their part-time services upon the basis of fees for attendance. For each member of the central trust a deputy or substitute member would require to be appointed in the same manner as the principal trustee, whose place he would take when he was absent, and with whom he should be in consultation. The trust should meet as a full board upon all occasions. Leave of absence from meetings would require to be asked and received, except for emergency cases due to health. A measure of non-attendance would result in disqualification from representation upon the trust. The trust should settle all matters by vote, the chairman to have an additional or casting vote.

The position of chairman and vice-chairman should be whole time and highly salaried. The chairman should be appointed by the government transport department for his ability to exercise a judicial faculty rather than an administrative faculty. The latter function should be delegated to the vice-chairman, who would be elected by the members of the central trust.

The detailed composition of each trust would require minor modifications to suit each individual country, but its constitution should be generally along the following lines:—

Judicial chairman.
Executive vice-chairman.
One representative of each of the following:—
Foreign shipping.
Home shipping.
Coastal shipping.
Inland water transport.
Railway transport.
Road transport.
Lighting and buoying service.
Port labour.
Imported raw materials
Imported food stuffs
Imported manufactured goods
Exported manufactured goods.
Exported coal or minerals.
The municipalities.
Harbour Engineering consulting expert.
Harbour financial expert or economist.
Legal expert.
Government through Ministry of Transport.
Government through Admiralty or Naval Service.

Six representatives of ports according to geographical groups. It is probable that the port representative would be the chairman-director of the principal port in his group. The actual number of such groups might have to be varied slightly to suit individual cases, as might the number of shipping and trade representatives in accordance with their relative importance and the revenues which they contribute.

Local Commission—Functions:

The controlling body in each port should be in the form of a commission which would function in a manner generally similar to the central trust, but dealing only with affairs concerning its own port or local minor ports under its control.

The commission would be responsible for the finance of its own port, i.e., for its working and maintenance and for the contribution of its quota to the revenue of the central trust. It would have powers to execute minor capital works and provide plant out of its own revenues up to a figure to be predetermined for each port. The sanction of the central trust would be required for all items in excess of this, or for which a grant would be needed from the central funds.

The rates should be fixed by the local authority in a manner similar to that at present in force in the trust-owned harbours. The rates derived from the trades normally handled by the harbour should be sufficient to cover the working expenditure and maintenance of the harbour, and the capital cost of all smaller items of plant below a certain figure, together with the interest and redemption charges of its share of the central capital fund. This share might be made proportionate to the average tonnage of vessels or value of goods passing through the port over a number of years. The fairest distribution of these charges is that at present in many ports. The total charge should be approximately equally divided between vessels and goods, and the individual charges varied in accordance with the expenses of the accommodation required by goods and vessels and the regularity or otherwise of their sailings, and the ability of the goods to pay in accordance with their intrinsic value.

All ports, while retaining a large measure of independence, would function as parts of the same organisation with consequent interchange of plant and personnel and the resulting economies where unnecessary duplication has occurred.

As in the central trust, the functions of the commission should be more judicial than executive. It should decide all questions by vote. It is intended that it should lay down only the principles of the detailed policy, and decide issues of major importance, leaving all minor matters of routine for the decision of the chief official and execution by the routine staff.

Local Commission—Constitution:

The commission should be composed of about fifteen members, appointed or elected by those qualified to do so, to represent the various activities which have an interest in the port. The members should serve for periods of five years, and one-fifth of the members in rotation should retire annually and be eligible for re-election. There should be one representative only in each category, assisted by a deputy or substitute member, who would be permitted to attend meetings for his own information but only to vote when the principal member was absent.

The chief executive officer should be constituted the chairman-director of the commission, and occupy a highly salaried full-time position. He should be appointed for life until retiral under age limit. He should be assisted by his full-time chief engineer, who should also have a seat upon the commission and a voice in its deliberations (that is, if the chairman-director did not act as engineer as well). The other members of the commission should be elected or appointed to represent the individual needs of the port in question, the constitution being upon the following lines:—

Chairman-director.
Harbour engineer.
One representative of each of the following:—
Foreign shipping.
Home shipping
Coastwise shipping.
Inland water transport.
Railway transport.
Road transport.
The Government through Ministry of Transport or Admiralty.
Port labour.
The municipality.

Six representatives of the traders, appointed by chambers of commerce, corn exchange, exporters' association, etc., in accordance with the tonnage of trade passing through the port or the revenues contributed.

The members of the commission should receive remuneration upon an attendance basis, but upon a scale suited to compensation for loss of time and expenses. A measure of non-attendance would constitute a disqualification.

For the ports of very large size a commission similar in constitution to the central trust might be required, while for minor

Port Administration—*continued*

ports the number of members could be reduced. Small ports should be placed under the jurisdiction of adjoining ports of larger size and operated as a part of them.

The Chairman-Director.

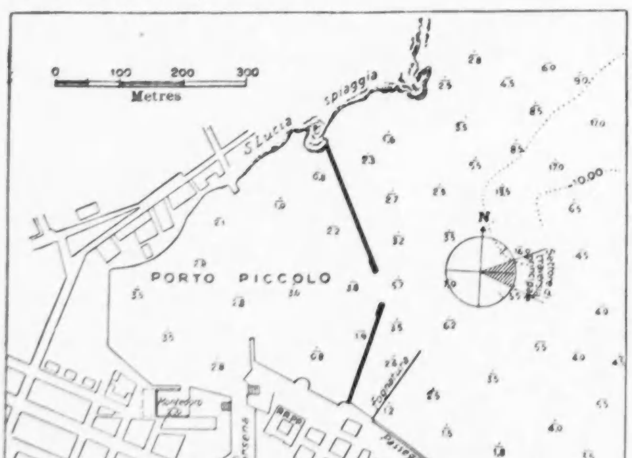
The chairman-director should be responsible for all matters of routine, discipline and adjustment, the intention being so to strengthen his position that he would be, for the individual port, the final authority for all matters except those involving questions of policy, capital expenditure, and questions of rates or disputes involving considerable sums of money. He should be given complete jurisdiction upon all matters involving money of a sum below a figure to be pre-determined by the central trust, in accordance with the size and trade of the port which he was administering, and a clear ruling would have to be given as to what was within his competency. In this routine work he should receive the advice and assistance of his commissioners. It is proposed that his powers should be akin to those of the managing director of a large company.

The chairman-director would be appointed by the local commission, subject to the approval of the central trust. In the event of a substantial majority of the commission experiencing extreme dissatisfaction with his policy or abilities upon matters within his competence, they should have the right to appeal to the central trust for his removal, before whom he would have the right to appear. The chairman-director would carry out all matters of routine administration through the subordinate officials.

There may be some disappointment that I have confined my remarks to general principles, and put forward a scheme which would suit any industrial country, instead of dealing primarily with the question of port administration in Great Britain. I have done this for a set purpose, because in this country there are so many and varied forms of administration and so many and varied interests to consider, that it is very difficult to approach the problem with an impartial mind. After laying down one's principles in general terms, the adaptation of these to a particular country can be done quite easily and in a more unbiased way. When one considers the recent revolutionary changes in public utility administration in Great Britain and the interference with the rights of the individual—to quote a few examples, the railway amalgamations in 1921, the formation of the London Passenger Transport Board, the formation of the Central Electricity Board, and the Traffic Commissions—I feel that my proposals would not be so difficult to realise in this country as a preliminary consideration might lead one to imagine.

New Breakwater at the Harbour of Syracuse

The following particulars of a pair of new breakwaters recently constructed at the entrance to the smaller harbour at the Port of Syracuse, Sicily, are extracted from the Annali dei Lavori Pubblici, issue of April last.



Plan of the Small Harbour of Syracuse

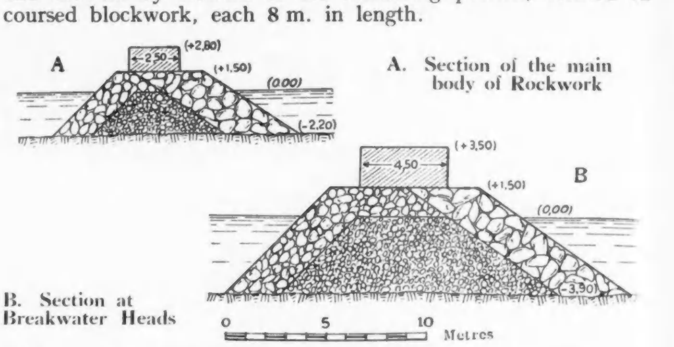
Porto Grande = Large Harbour
Porto Piccolo = Small Harbour
Fognatura = Outfall Sewer
Darsena = Dock or Basin
Spiaggia = Beach

The object of the work is to prevent the propagation within the Porto Piccolo, or small harbour, as also in that of the Porto Grande, or large harbour, of storm waves coming from the Eastern sector of the compass. The two defensive moles have been constructed at the entrance of the former harbour, firmly rooted, one towards the South to the Talete Quay and the other towards the North to the coastline at the beach of Santa Lucia.

The lengths of the breakwaters at sea level are 171 metres for the Southern arm and 230 metres for the Northern arm. Between the outer extremities is a space of 50 metres, which constitutes the width of entrance to the harbour.

Structurally, the breakwaters are formed of a base mound of stone rubble of different categories levelled at the summit height of 1.50 m. above mean sea level, with slopes of 5 : 3 externally and 1:1 internally, and a summit width of 5 metres, except the portion at the heads where the width is 8 metres.

The rubble is crowned with a superstructure of walling in cement with a sectional area of 4.50 m. by 1.70 m. at the heads, and 2.50 m. by 1.30 m. in the remaining portion, formed of coursed blockwork, each 8 m. in length.



A. Section of the main body of Rockwork

B. Section at Breakwater Heads

The result of the aforesaid constructional work has been a notable reduction of the influx of storm waves from the tempestuous quarter, which used to traverse the inner dock and penetrate to the great harbour, rendering it impossible to berth steamships at the San Antonio pier.

The cost of the complete undertaking was 827,000 lire, and the work gave employment to 19,334 workmen.

The Harbours of Manchukuo

The following particulars respecting the Harbours of Manchukuo are extracted from a recent article in The Far Eastern Review.

The coastline of the country is short as compared with its vast territory, and the country is not blessed with good harbours.

Only three ports, namely, Antung, Yingkou and Hulutao may be mentioned, besides Dairen, which is in the Kwantung Territory. Both Antung and Yingkou freeze in winter, which is a great detriment to the growth of good harbours. However, the development of national industries and the expanding radius of Manchukuo State Railways has necessitated additional outlets to the sea, and since commercial relations with North China, Mongolia and other countries have become closer, rapid establishment of habour facilities has become very urgent. The reconstruction of Antung and Yingkou Harbours and the construction of the Port of Rashin, which forms the future outlet to the sea from North-Eastern Manchuria, together with that of the Port of Hulutao, an outlet of South Manchuria and North China to the sea, are essential for the progress and development of the industrial resources of the hinterland. By the end of 1937 the first-stage construction work at Rashin and Hulutao had been completed and opened with the capacity for handling 3,000,000 and 170,000 metric tons of cargo a year, respectively. The two ports are still under construction in accordance with second-stage construction work.

Considerable improvements are also being made at the Port of Yingkou and Antung. After the completion of improvement the capacity for handling cargo at Yingkou and Antung will be 3,000,000 and 2,000,000 metric tons, respectively. By adding 4,000,000 metric tons for Hulutao Harbour and 9,000,000 metric tons for Rashin Harbour, the total tonnage for the handling of cargo would reach some 18,000,000 metric tons a year. Moreover, parallel with the progress of the development plan, the facilities of the Port of Dairen will become insufficient. Attention is being given to improving this port.

Staff Changes at South Wales Docks.

The Great Western Railway Company have made the following appointments to take effect from the 28th ult.:—

Mr. L. E. Ford, dock manager at Cardiff and Penarth, to be principal assistant to the chief docks manager; Mr. H. B. Smith, dock manager at Newport, to be dock manager at Cardiff and Penarth; Mr. T. J. Edmunds, dock manager at Port Talbot, to be dock manager at Newport; Mr. T. Carpenter, assistant dock manager at Barry, to be dock manager at Port Talbot; Mr. W. Jeffers, outdoor assistant coal, shipping and traffic section, Cardiff docks, to be assistant dock manager at Barry.

New Wharf at Bowater's Mersey Paper Mills Ellesmere Port*

By J. C. MARTIN, M. Inst. C.E.

Discussion

Mr. R. D. Brown (Chairman) said that it had been his great privilege to serve on this work in collaboration with the late Mr. H. A. Reed, and he would like to add a word or two which might perhaps be useful to anyone who in the future had to design a similar structure.

This wharf made a considerable departure from established practice. The governing factor was, of course, the nature and quality of the rock. Usually, when one encountered rock as a foundation material, one was content to impose very substantial loads upon it.

On the Bowater site, however, that general proposition did not apply. The rock there belonged to the New Red Sandstone Series. It could not be relied upon to stand up permanently on a vertical, or nearly vertical, exposure. It weathered and broke off, until in the course of time it reached what might be called an *apparent* angle of repose of about 1 horizontal to 5½ vertical. He used the word "apparent" advisedly.

Berthing of first Ship at Wharf

The rock might stand to a fairly steep face for many years, but it was unreliable. Large patches might fall off from time to time. Indeed, during construction, in spite of all the care that was taken not to damage the rock, i.e., by excavating a strip along the face by hand labour only, without the aid of explosives, there had been one sudden fall of about 300 tons of rock, and, unfortunately, one man was killed and several injured.

The dip of the rock on this site was about 15 degrees towards the west, that is, away from the face, and it contained cracks or fissures which extended at all angles from horizontal to vertical. Some of these cracks were plainly visible and others mere hair cracks, scarcely discernible. In substance, the rock varied from "hard" to "soft and friable." The main outstanding conditions governing the design on this site became therefore:—

(1) No serious load or stress must be applied upon or near the edge of the vertical face of the rock.

In addition, of course, certain other conditions had to be complied with, which were common to all wharves, and included the following:—

(2) The design must be the cheapest possible structure that would efficiently carry the specified loads.

(3) The structure must have reasonable margins of safety against—

(a) Overturning;
(b) Sliding forward upon its base; and
(c) Settlement.

(4) It must have the capacity to resist—without sustaining more than merely local damage—a heavy accidental blow from a ship.

(5) Ease and speed of construction.

(6) Minimum of maintenance costs.

Now, in this case, the rock face had a vertical exposure of about 44-ft. The problem became then, how to carry the load down to a safe point below the Canal bottom, without imposing any severe stresses at or near the top edge of what might be called a small cliff.

Many alternative designs had been prepared and considered. Indeed, these alternative designs might well form the subject of a separate paper. Ultimately, the final design, as shown on the drawings, was adopted. Massive pillars at 33-ft. centres carried the main front loads down below dock bottom, and massive triangular members carried the main back loads (a) partly on to these pillars, and (b) to a larger extent down to sound rock at a point situated well behind the exposed face. Thus it mattered very little what happened to the face of the rock. If in the future any large pieces were to fall off, forming hollows or caverns in the rock, no great harm would be done. The rock, therefore, was actually left with a large amount of freedom to adjust itself to a very considerable "angle of repose"—if these words might be applied to a substance, such as rock.

Looking down upon the foundations of these triangular members, it would be seen that they were tapered, or wedge-shaped, in plan. This point had often been misunderstood. On first appearances the wedge shape gave them a dove-tailing action, which tied them to the rock. So it did, so long as the rock remained in a sound condition. They were tied to the rock, but actually the design did not need this dovetailing support for its stability. The foundations were tapered, so that if any tendency should develop towards a heavy fall of rock, such tendency would not impose heavy overturning moments upon the structure. The dovetailed shape would leave the rock free to move, and consequently would not affect the stability of the design.

With regard to the question of the high level versus the low level deck, mentioned by Mr. Martin on page 2 of his paper, Mr. Brown said that if a high-level deck had been carried out to the face-line, in accordance with normal practice, this would have given 24-ft. more width at the high level, or about three-quarters of an acre over the length of the wharf. The necessary superstructure would, however, have added considerably to the cost, and it had been decided that the acreage of additional land was not worth the money.

If, on the other hand, a low-level wide deck had been adopted, this again would have entailed additional cost for (a) the approach railways in cutting, with gradients to overcome a rise and fall of about 15-ft., and (b) more excavation, with probably a heavy retaining wall.

The crane makers, Messrs. Stothert & Pitt, Ltd., agreed to provide cranes that would meet the severe conditions imposed by the unusual shape of the wharf, and in the end the design shown on the drawings was adopted. Mr. Brown added that Messrs. Stothert & Pitt, Ltd., carried out their part of the work in a very able and efficient manner.

Mr. Brown also took the opportunity of saying how great a pleasure it was to look back on the construction of this wharf, where all concerned—Messrs. Bowater's, the contractors, the clerk of works, and the engineers—worked together in such great harmony, and although at times there were, of course, difficulties and anxieties, the best possible team-work prevailed throughout.

Mr. Shaw, of Messrs. Bowater's, said that Mr. Martin had mentioned certain unusual aspects of the wharf from a design and construction point of view, but from an operating point of view, it was obvious during the designing period that the construction of the railway tracks at such a height above the water level, and at such a distance from the wharf front, might give a low rate of cargo discharge, unless these factors were compensated for in some way.

Prior to the construction of the wharf, the Company's ships had discharged at the Ellesmere Port wharf of the Manchester Ship Canal. At this wharf the railway tracks were placed at a comparatively low height above the water level and were adjacent to the wharf front. From a shipping point of view, it was essential to give as quick a rate of discharge on the new wharf as previously obtained at the Canal Company's wharf.

In the case of Bowater's wharf, the distance which the load must travel in hoisting and slewing was much greater than at the Canal Company's wharf. To maintain the same rate of discharge therefore necessitated as high slewing and hoisting speeds as possible. The hoisting speed of 300-ft. per minute was unusually high, but in practice no difficulty had been experienced, and a very satisfactory rate of discharge had been obtained.

* Paper read March 1st, 1939, before Manchester and District Association of the Institution of Civil Engineers. Reproduced by permission in last month's issue of this Journal.

New Wharf at Bowater's Mersey Paper Mills—continued

On the other hand, the travelling speed of 50-ft. per minute was lower than normal, but it was thought advisable to keep this speed low on account of the unusual crane structure; as there was little need of travelling when the cranes are actually discharging (no railway wagons passing through the structure as in the usual design of cranes), the low travelling speed had not been of much detriment.

The cabin of the crane was arranged high enough for loading paper into large vessels, and the crane structure was designed so that the cranes might satisfactorily clear overhanging bridges of large vessels when travelling along the wharf. The height of the structure and the additional ballast due to the small tail radius, to permit two cranes to work back to back on one hatch, increased the weight of the crane, and it was decided to arrange eight wheels, two at each corner, to spread the load.

The wharf had been eminently satisfactory in every respect, the only criticism being a slight subsidence under a portion of the railway deck, due to crumbling of the sandstone hardcore filling and the loosening of one or two wooden fenders.

In closing, Mr. Shaw endorsed what Mr. Brown said about the very happy relations between the officials of the Company, the engineers and the representatives of the contractors which existed during the work. He also mentioned the very efficient way in which the construction was carried out.

Mr. Wildsmith said that it was remarkable how so large a contract was kept to a time table. His experience was that even very small jobs often got behind schedule. He asked what methods were used to support the chequer-plate over the cable trench, how the rails were fixed to the crane beams, and what was the manner of replacing the needle point on the floating rock-breaker.

Mr. Hodgson congratulated the author on having given such an interesting paper, and was delighted to hear of the happy relationship existing between the consulting engineers, the resident engineer, the Bowater Company's engineer and the contractors.

Mr. Hodgson also congratulated the engineers responsible for the design, in having produced such an economical layout, and was sure that the Canal engineers were not unduly anxious when the dam was about to be released.

The finished work had a dignity in keeping with its surroundings, its delightful lines giving the structure an appearance of great lightness and at the same time producing an impression that it had ample strength to withstand the shocks and heavy loads which a structure of this character is called upon to carry.

The design of the steel reinforcement was a model of simplicity, the diameter of the rods and stirrups used making certain that the steel, after fixing, could be kept in its correct position during concreting, a very important point in a structure subjected to the decomposing action of sea water. He noted that provision had been made for contraction joints every 195-ft. In practice, had this distance proved satisfactory?

It was probable, owing to the nature of the work, that no very large range of temperature would be encountered, but, on the other hand, in spells of dry weather there might be considerable drying out of the concrete members. This would cause a shrinkage which might develop stresses capable of producing cracks in the beams. For this reason he thought it would have been better to provide contraction joints in the work about every 100-ft., or every third pier. It would be interesting to know if any cracks had developed.

He noted with interest that Class II concrete (1 : 2 : 4 mix) had been used for the beams, while Class III concrete (1 : $2\frac{1}{2}$: 5 mix) had been used for the piers and counterforts. As the piers, being partly submerged, were the most vulnerable portions open to attack from sea water, it would be interesting to know why a poorer quality of concrete had been used. He thought, unless special precautions had been taken with the grading of the fine aggregate, that in time the sea water would be able to attack the steel and so cause considerable damage to the piers.

As the structure was not very old, damage might not have occurred as yet, but it would be interesting to know if there were any signs showing of the steel reinforcement beginning to rust, also what cover of concrete was allowed over the steel.

Mr. Hodgson then discussed briefly the importance of the grading of the fine aggregate in concrete work, and by means of lantern slides showed the grading of ordinary sand compared with an artificially produced sand made by crushing rock.

The mixture curves for Classes I, II, III and IV concrete were also shown, and it was seen, with the sand grading, that all the curves departed a considerable distance away from the zone of maximum density. On the other hand, in the case of concrete made with sand from the crushed stone, the mixture curve coincided with the zone of maximum density.

To illustrate the importance of producing a mixture curve which coincided with the zone of maximum density, Mr. Hodgson showed a slide of two specimens under a water pressure test. In the sample made, using ordinary sand, considerable water was seen to be passing, while in the case of one made with a sand from crushed rock the specimen was seen to be bone dry.

He said that during the last few years the quality of cement had been greatly improved, and to obtain the best results it was necessary to use a sand, the grading of which could be controlled within fine limits.

Mr. Marsh said that when he visited Bowater's wharf some time ago, he was impressed with the design of the cranes, but expressed a doubt as to the safety of the control method, there being no stop on the control crank. He also asked about the rails on the upper deck; as these were let into the slab, did not the grooves get choked with china clay, and how were these grooves drained of surface water?

Mr. Harbottle asked if there was not an element of danger in the construction of the safety trench. He also asked the method of excavation and drainage of the trench.

Mr. Cowin thought that the construction of a wave wall was unnecessary, in view of the fact that it had been explained that the counterforts were safe, even if the rock fell away at the face. He remarked that although precautions were taken to stop pieces of rock falling into the Canal, the dragline excavator, which was perilously perched on the dam, would have created a bigger obstruction had it fallen into the Canal.

Dr. Ferguson thought that the construction method was somewhat of a contradiction. Whilst the faulty state of the rock at this point had been emphasised, the whole job, in his opinion, had been jeopardised by using this "faulty" rock as a temporary dam. Did the contractors find the dam absolutely safe?

The Author, in reply, explained that although not shown on the drawings, steel stanchions in the cable trench carried a joist which supported the chequer plate. Rag bolts were used to secure the crane rails to the beams. With regard to the floating rock-breaker, the needle point was held in position by a friction ring, which was shrunk on over the needle. The joints shown at 195-ft. centres were not expansion, but contraction joints and no cracks had been noted since the completion of the wharf. Two-inch cover had been allowed on the steel. It was the practice on the Canal, where concrete was in mass, no matter whether under water or not, to use Class III concrete (approximately 1 : $2\frac{1}{2}$: 5), and as far as could be seen the salt water had no deleterious effect on the piers.

The Author asked Mr. G. W. Shaw to answer the question about the cranes, and **Mr. Shaw** explained that the crane operators had not experienced any difficulty or danger in their working.

The Author, continuing, said that with regard to the choking of the rails by china clay they did choke up, but the same trouble was experienced wherever rails were let into a wharf, and it was a simple matter to clear the grooves with a small scoop. The drainage of the rail grooves and slab on the higher level was carried out by means of cross drains which flowed to manholes, of which there were five, and thence to the Canal.

The excavation of the safety trench was not in any way dangerous; indeed, it proved to be a profitable venture. The rock was broken with pneumatic drills and by hand, and was hoisted to the upper level by the crane and deposited in wagons. The excavation was done in two cuts, and a 4-in. dia. pump was sufficient to remove what little water found its way into the trench.

The wave wall was constructed whilst building the wharf as a matter of economy. Erosion was common on the Canal, and has to be made good by means of limestone and cement (a costly and intricate business in the wet). The precarious position of the dragline excavator on the dam did give rise to a certain amount of trepidation, and the contractors certainly took risks, but the rock in the dam proved to be particularly good.

Harbour Developments in Malaya.

The recently issued report of His Majesty's Trade Commissioner at Singapore on the Economic and Commercial conditions in Malaya, published by H.M. Stationery Office, price 2s., contains an intimation of impending developments at the harbour of Port Swettenham. Port Swettenham is a Federated Malay State Railway Port, and the number of ocean-going steamers which call there has increased considerably during the last ten years. In 1931 the Imperial Shipping Committee were asked to report on a scheme for the provision of additional harbour accommodation at Port Swettenham and, although they reported favourably on one of the schemes submitted, the matter was left in abeyance as the trade through Port Swettenham declined considerably during the years of trade depression. In 1937 the tonnage of cargo handled at Port Swettenham rose again to the pre-depression figures, and the question of carrying out some extension of the port facilities is now under consideration.

*The Handling and Storage of Grain**

By ERNEST BEALING, A.M.I.Mech.E., A.M.I.Struct.E.

Silos

A SILO has obvious advantages over a floor warehouse, so far as labour saving is concerned, but some grain, particularly home-grown English and other soft wheat, is occasionally stored on floors, because grain stored in high silos is subjected to great pressure, which has a tendency to raise the temperature of damp wheat, and when stored in high silos, it is necessary to turn it over at frequent intervals.

A silo, for the same capital outlay, will accommodate twice as much grain as the floor system.

Silos may be either rectangular, circular or hexagonal, and may be built of wood, brick, steel or reinforced concrete. Timber for building silos is light, strong, inexpensive and a non-conductor of heat. One of the most usual forms of construction is the interlaced type, consisting of flat strips of wood nailed one on top of the other, and overlapping at the corners, so that alternately a longitudinal and a transverse batten extend past the corners.

The disadvantage of brick is its weight, consequent necessity for heavier foundations, and the need for making the division walls thicker than when using wood.

Steel or iron has the advantage that the walls can be very thin, but as they are good conductors of heat, and can transmit to the grain the changes of temperature, they are detrimental.

Reinforced concrete is the material most largely used at the present time, and consists of steel rods embedded in concrete.

There is very little difference in cost between nests of 12-ft. square and 12-ft. diameter bins; larger circular bins show an economy. In a square or rectangular bin, walls are designed as a series of horizontal beams, and reinforcing is requisite near both faces of wall, but in circular bins, the concrete carries the vertical pressure, and transmits the lateral pressure to steel reinforcing designed to resist bursting.

In view of the many different kinds of grain to be handled, it is desirable to have a number of relatively small bins, rather than a smaller number of large bins, as it may be difficult to keep a large bin filled with grain of one kind, with the result that the excess volume is dead storage. Furthermore, it is possible for a consignment of grain of poor quality to be delivered into partly-filled bins containing high-grade grain, which would lower the grade of the whole of the grain in the bins, and whilst this may not be a serious matter if the bins are small, it certainly would be in the case of large bins. Although large bins cost relatively less than small bins, it is customary to have a number of each, and in the case of square or rectangular bins, the small bins are usually half, or quarter, the size of the larger ones; in the case of circular bins, the interspaces serve this purpose.

In the case of small silos, the forms for the concrete walls are moved every three or four feet, but for large silos, the reinforced concrete bins are now invariably constructed by means of moving forms, and the method is to pour concrete continuously into a shallow mould of the shape of the building it is desired to construct, the mould being slowly and continuously moved vertically upwards till the required elevation is obtained.

The usual method is to have forms of steel plate or timber 4-ft. deep, with spaces between corresponding to the thickness of wall, the forms being connected together by means of yokes over the spaces. At each intersection of the bins, there is a vertical steel column, to which is attached a bracket, and from these brackets the forms are suspended by means of screwed rods and nuts, the arrangement being such that, by rotating the nuts, the forms are raised. On the top of the forms is laid a timber platform, forming a complete timber floor over the whole area, with spaces corresponding to the thickness of walls and columns. For the purpose of raising the forms evenly, a group of men are organised, under the control of a single charge hand, and at a signal from a whistle by the charge hand, the nuts are given a turn or half-turn, as pre-arranged, thus raising the forms up to ½-in. at a time, and the men proceed to the next line of columns, to await another blast on the whistle.

The placing of the concrete in the forms is carried out by another company of men, organised into groups under the control of charge hands, and a third group of men are responsible for fixing the reinforcements into position.

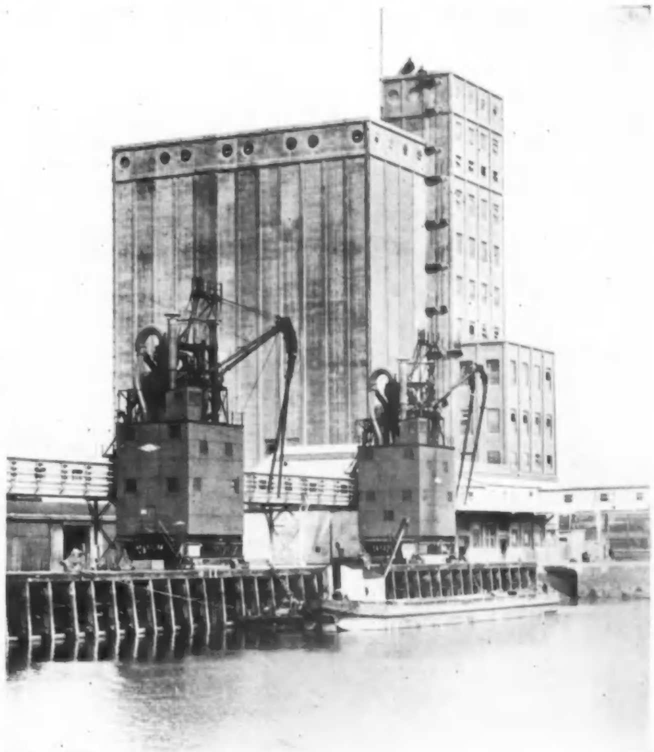
By this method of construction, it is possible to maintain an average of 6 to 8-ft. vertically per day, and if progress is 6-ft. per day, with 4-ft. deep forms, it will be seen that the concrete is exposed below the form 16 hours after pouring. As quickly as the green concrete is exposed, it is rubbed smooth, the men engaged on this work standing on a platform supported from the forms.

It may prove interesting to refer to the largest grain silo in the British Isles, recently built in Liverpool, by this method. The silo consists of two blocks of bins, with a central receiving tower; each block of bins consists of 141 bins, 11-ft. by 9-ft. by 6-ft. thick walls, height of bins 116-ft. The South block was built in 22 days, during which time there were used 535 tons of steel, 11,000 tons of crushed granite, and 2,150 tons of cement. The North block was built in more favourable weather, in 15½ days.

It should be mentioned that the conical bottoms of the bins can be built in either reinforced concrete or steel, but they are usually built in steel.

Intake Plant from Ship

In the case of a small silo, where the grain is brought alongside by barge or coaster, the intake plant is usually fixed to the wall, but in the case of large silos—where ocean-going vessels 4 to 500-ft. long are to be unloaded—a travelling intake plant is necessary to unload from the various holds. The intake plant can either be a bucket elevator or a pneumatic plant.



Intake Plant for New 20,000-ton Silo at Belfast—Capacity, 300 tons per hour.

Bucket Elevator

Until comparatively recent times (i.e., until the War), this was the usual form of intake, and it consists essentially of an ordinary belt and bucket elevator, supported in fulcrum bearings at the end of a hinged-balanced girder, or jib, which can be raised or lowered to suit the state of the tide, and the varying positions of the vessels when loaded and empty, the elevator delivering into a chute of the telescopic type, feeding the grain to the desired point. Where the variation in depth for the boot of the elevator is very large, the elevator leg is made telescopic.

The great advantage of an elevator is the relatively small power consumption, as an elevator to lift, say, 100 tons per hour a height of 50-ft., would require a theoretical h.p. of 5.65, although, in actual practice, this may be increased by 125% to, say 15 h.p., for a barge or ship elevator, due to the dredging at the boot, and making allowance for inefficiency of bearings, drives, etc.

Pneumatic Plants

Since the War, pneumatic or suction plants have been developed, and are now generally superseding the bucket elevator for ship unloading. The chief advantages of the pneumatic elevators may be summarised as follows:—

1. The number of men required to operate a pneumatic plant at good average capacity is less than that required for a bucket elevator.
2. The men in the hold work in a clean atmosphere.
3. The pipes can be swung into the ships' holds, and discharge started very quickly.
4. In a cargo awkwardly disposed, and where the bucket elevator can reach only a small part of it, the pneumatic elevator can reach directly every portion.

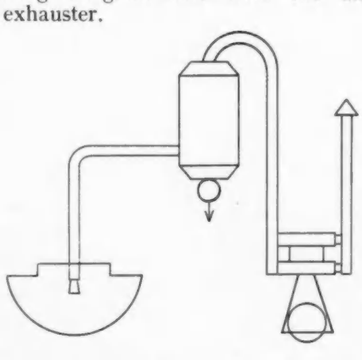
* Paper recently read at the Canterbury Technical Institute by the London Representative of Messrs. Spencer (Melksham), Ltd.

Handling and Storage of Grain—continued

5. In a cargo composed of parcels of grain separated by sheets, in which a bucket elevator would be of little use, the pneumatic plant can deal effectively with the whole cargo.
6. By virtue of the flexible piping, poop and bunker hatches (into which it is impossible to lower a bucket elevator), can be easily dealt with.
7. The pipes of a pneumatic plant can be passed through a comparatively small opening in the hatch, which is a distinct advantage in wet weather.
8. In the case of grain which is damp or slightly out of condition after the voyage, its passing through the pneumatic plant materially assists in restoring its condition, due chiefly to the drying effect of the air, and the breaking up of clotted masses while passing through the pipes.
9. The average output of a pneumatic elevator, if properly worked, exceeds that of a bucket elevator, when working on small cargoes, parcels and shallow vessels.
10. A certain amount of dust is separated from the grain during its passage through the pipes, which can be discharged from the plant separately, or returned to the grain, as desired.

The essential parts of a pneumatic Grain Discharging Plant are:—

1. An exhauster of either reciprocating or rotary type.
2. A receiver into which the air and grain is sucked.
3. A discharger, which discharges the grain from the receiver without breaking down the vacuum in it.
4. A nozzle, with means of regulating the inlet of air.
5. Grain piping, for connecting the nozzle to the receiver, consisting of flexible, rigid and telescopic pipes.
6. The necessary air piping for connecting the exhauster to the receiver, and
7. A separator for removing the grain dust from the air before it reaches the exhauster.



The exhausting unit, either rotary or reciprocating, is connected to the top side of the receiver, the grain-carrying pipe with nozzle being also connected to the latter, but at a point near the bottom. The grain and air enter the receiver at this point, and, as the receiver is of large diameter compared with the diameter of the pipes, the air, on entering, loses its velocity, and the heavy grain falls to the bottom, the air being exhausted as slowly as possible through the pipe at the top which is connected to the exhauster. In the best practice, the receiver is of a diameter sufficiently large to allow a cyclone Dust Separator to be fitted inside, the air being drawn through this separator on its way to the outlet at the top, which is connected to the exhauster. The bottom outlet of the separator is connected to the conical bottom of the receiver, and the dust from it is led, by means of a suitable chute, into the grain discharger, or is fed out, by means of a small rotary dust discharger, to the hopper under the grain discharger. An additional cyclone-type Separator and Dust Discharger may be used between the receiver and the exhauster. The cycle of operations will be easily followed by referring to the diagram.

The grain pipe line usually consists of one or more hinged pipes connected to the receiver at one end, and fitted at the other with a right-angle bend, to which the vertical pipes are attached. These pipe lines are usually attached at the receiver end to an airtight universal joint, which may consist of a specially constructed ball joint mounted on a swivel, or of a forked universal joint. In these cases, a winch is used for raising and lowering the pipes, to get them easily in and out of the ship or barge. It is usual to fix a flexible pipe immediately under the right-angle bend, and at least one other immediately above the nozzle. The right-angle bend must be of robust construction, and fitted with a heavy renewable plate, to resist the wear due to the velocity of the grain which impinges on it.

Several forms of nozzles are used, including the straight and angular type, and they usually consist of a central tube with an adjustable bell-mouthed end, and an outer sleeve which forms a passage for the admittance of air.

Flexible pipes consist of end tubes connected by a series of tapered steel sections fitting one into the other, the whole being covered with an outer sleeve of india rubber and canvas, or several layers of proofed canvas.

The grain which has been deposited at the bottom of the receiver is fed out by means of a discharger, which may be of the rotary or the oscillating type. The rotary discharger consists of an outer cylindrical casing, in which an internal drum, mounted on a central shaft, rotates; the drum is divided into six or eight compartments (according to the size) by radial divisions, the compartments in turn passing under the opening in the receiver. As the compartments pass, they are filled with grain, which is discharged when they reach the opening at the bottom of the outer casing. The air in the empty compartments, after discharging the grain, is, of course, at atmospheric pressure, and before the compartments reach the opening at the bottom of the receiver they pass a pipe connection which puts them in communication with the interior of the receiver, and the pressure of air in them is then reduced to the same as that at which the grain is discharged.

The oscillating type of discharger has an air-tight chamber, fitted internally near the top with a hinged door (which shuts against a rubber joint), and on the outside of the bottom with an exactly similar door. The appliance operates as follows:—Just as the bottom door is closing after discharging the contents of the chamber between the top and bottom doors, a rotary air valve (operated by the discharger gear, and synchronised with it) opens and connects the discharger with the receiver, thus equalising the pressure in them. As soon as this occurs, the top door is opened, and the grain in the receiver runs into the discharger. The top door now closes, and the rotary air valve, before mentioned, connects the body of the discharger with the atmosphere, thus again equalising the pressure, so that the mechanism of the discharger may freely open the bottom door and allow the grain to run out into a hopper or other receptacle below. The doors of this discharger are opened alternately by push rods operated by a revolving cam, which is arranged to hold the door open for a certain period and then allows the operating rods to drop, when the door closes instantly by reason of its own weight. As there is no positive attachment of the rods to the cam, it will be seen that no damage can be done to the operating gear, should a foreign substance in the grain—such as a piece of wood or a bolt—be caught between the door and its seating as the door closes.

For creating the vacuum necessary to operate a pneumatic plant, either a rotary exhauster or the vertical reciprocating pump is used. With the rotary type, when the nozzle is withdrawn from the grain, or its mouth is only partially immersed in the grain, a free influx of air is allowed to the suction, causing a very heavy overload to be thrown on the motor and driving gear.

In the case of the reciprocating vacuum pump, however, the load upon the driving gear is always directly proportionate to the vacuum and to the work being done. For this reason, the reciprocating pump is the most economical for general use. The type almost universally adopted is the short stroke vertical reciprocating pump, as it has been found the most suitable for this class of work. The valves in these pumps are sometimes arranged in a space outside the cylinder, formed by an outer casing, although usually they are arranged in the top and bottom covers, half the number in each cover being suction, and the other half discharge valves. The valves vary in diameter, according to the size of the pump, and as many as possible are fitted in the space available, in order to reduce the velocity of the air passing through them.

It is important that the clearance between the piston and the cylinder covers should be as small as possible, and in the largest pumps this is about $\frac{1}{8}$-in. at the top side, and $\frac{3}{16}$-in. on the bottom side. The piston consists of a circular box casting, hollow inside, machined all over, and made as light as possible consistent with strength. Lubrication for the piston is found to be unnecessary, for quite as satisfactory results and efficiencies are obtained by machining the piston $\frac{1}{32}$-in. smaller than the bore of the cylinder, and turning three or four grooves on the rim; these grooves, when the pump is running with the piston just clear of the cylinder walls, form effective air locks, and prevent leakage of the air past the piston.

Having described the arrangement of a typical pneumatic grain elevator, and the component parts of which it is made up, it may be interesting to consider the performance of such a plant.

In a typical grain-discharging plant, in which the vertical lift of the grain is about 100-ft., and the length of the horizontal pipe is about 40 to 50-ft., the vacuum required to lift North American Wheat at full capacity would be about 10-in. mercury gauge at the pumps, on a pump plant, and about 11 to 11½-in. in a Turbo-Exhauster Plant fitted with dust filters of the fabric sleeve type. In dealing with oats and other lighter grains, a vacuum of 6-in. to 7-in. mercury gauge would be sufficient, the vacuum being varied as required by regulating the amount of free air entering the pipe system of the nozzle.

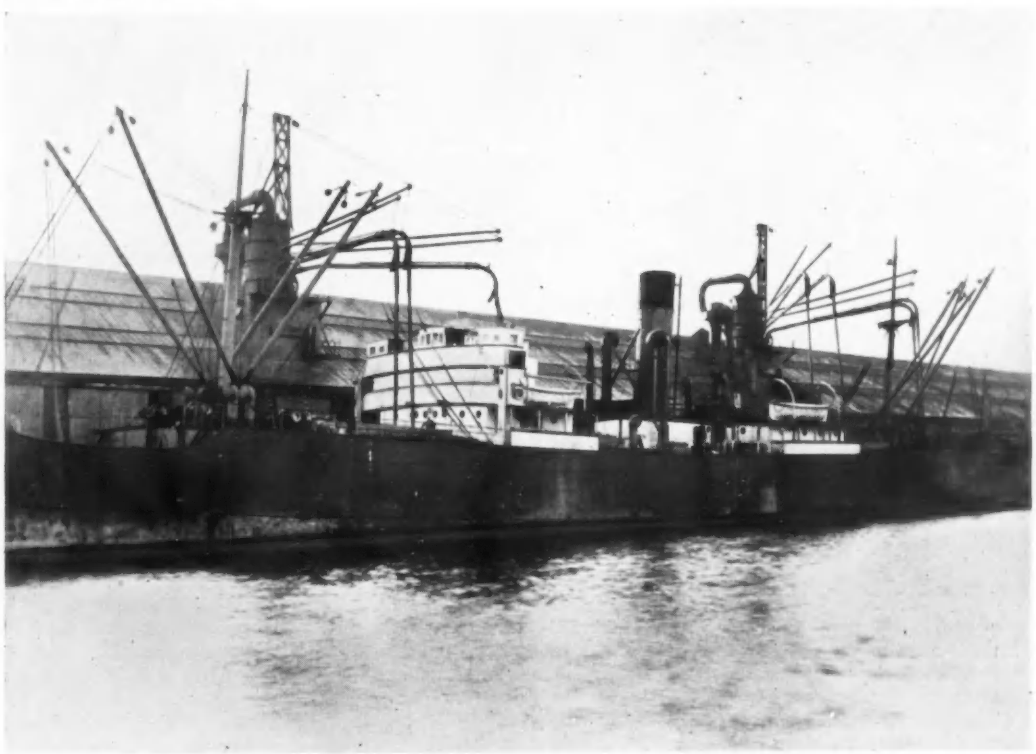
The vacuum required is, of course, dependent mainly on the vertical height through which the grain requires to be lifted, but for the lift mentioned, the figures given are good averages.

In lifting grain to the receiver, it is necessary that the air should have a suitable velocity for accelerating the grain sufficiently to raise it the vertical height required, and keep it in suspension during its transit along the horizontal—or nearly horizontal—pipe to the receiver. In order to accomplish this, free air usually enters the mouth of the nozzle at a speed of

Handling and Storage of Grain—continued

about 70 to 80 miles per hour, in the case of a plant working under a 10-in. vacuum. This vacuum represents the pressure at the suction branch of the pump or exhauster, and is not maintained throughout the whole system. For a vacuum of 10-in. at the pump in an average plant, the vacuum in the receiver would be approximately 9-in., and would vary fairly uniformly from this figure to approximately 2-in. to $2\frac{1}{2}$-in. just above the nozzle. The volume of free air, drawn in at the nozzle, increases in proportion to the increase of vacuum, in its passage through the pipe system, and consequently the diameter of the grain piping is usually increased gradually, in order to keep the velocity of the air at a suitable rate for the work required of it at each portion of the plant.

It is also desirable, at this point, to note that the air and grain do not travel with the same velocity, the velocity of the grain (as might be expected) being considerably less than that of the air which is lifting it. The air, as it is drawn in at the nozzle, exerts a force on the grain, causing it to follow the air, and the speed of the air must be more than sufficient to lift the particles of grain. As the air is drawn into the nozzle through the interstices between the particles, those nearest to the nozzle are sucked into the pipe with a considerable speed, but this acceleration diminishes as the grain proceeds up the pipe, until a limiting value is reached for the difference between the air and grain speeds for any given plant.



Pneumatic Intake Plant at Alexandra Dock, Liverpool—Capacity 600 tons per hour.

The whole of the air entering the nozzle is not drawn through the grain, or choking would occur, and to avoid this, a certain amount of air is allowed to enter, either by means of an auxiliary air inlet on the nozzle, or by adjusting the height of the bell mouth of the nozzel, so that air may enter over the grain. The amount of air required to lift the grain determines the size of the pump or exhauster to be used. This depends on the conditions to be met in any particular plant, and would generally amount to about 50 cu. ft. of air per minute per ton per hour of grain lifted.

Elevators

Whilst, in America, the term "elevator" is used when referring to a complete granary, in this country it is used when referring to a machine for elevating materials. An elevator consists of three main parts: the head, the boot and the intermediate work comprising the casing, buckets and the support for the buckets. As grain is a relatively light and small material, and is not injured when delivered at a high speed (provided it does not impinge directly on a hard surface), it is customary to run grain elevators at a speed of between 250 and 550-ft. per minute, and as, at this speed, the centrifugal force is sufficient to discharge the grain from the buckets clear of the vertical run of descending buckets, grain elevators are built vertically.

As it is not advisable to run ordinary chains at a high speed, the buckets are attached to belts, usually of rubber and canvas. The belting consists of plies of woven cotton canvas or duck, frictioned with a rubber compound, covered with rubber on the carrying side, the whole being vulcanised together in a uniform manner. The strength of the belt lies in the duck or fabric, the rubber covering merely acting as a protection. The fabric is graded according to the weight, in ounces, of a piece 36-in. long in the warp by 42-in. wide, and the usual grades are 28-ozs., 32-ozs., and 36-ozs., the 32-ozs. being the more common, with a tensile strength of about 365 lbs. per inch of width in the direction of warp, and the respective maximum working tensions in lbs. per inch width per ply are 24, 27 and 30. The rubber cover is supplied in three qualities of breaking strain, of 4,000, 2,000 and 1,300 lbs., the 2,000-lbs. quality being the most common for grain elevators, and this has an elasticity of 450%, and an adhesion between the piles of 17 to 18 lbs.

Usually, an elevator belt has a "friction surface" back (that is, one which has only a thin layer of friction rubber on the surface), and on the bucket side, a rubber cover of $\frac{1}{16}$-in., which helps to protect the fabric from wear caused by direct impact of grain; also, it resists the tendency of the forward edge of the bucket to cut the belt, when hanging forward on the down run.

An elevator belt is joined together by bending the two ends over, fitting a flat bar on either side with a radius on the edge to prevent cutting the belt, and bolting through the four thicknesses.

Elevator buckets are made of light material, such as 16-G sheet steel plate, built up with the flanged ends rivetted to the body, and a small stiffening plate in the centre. The shape has to be considered in relation to the discharge from the head pulley, but usually, grain buckets are fairly deep, with the top sloping at about 20°, and the front plate sloping at 52°. The length of buckets is usually 1-in. less than the width of the belt, but in large elevators, to reduce the load on the belt, and the tendency to bend buckets and pull the bolts through when passing over crowned head pulleys, the length of buckets is 1-in. less than half the width of the belt, and the buckets are staggered. Thus, on a 28-in. wide belt, the buckets would be 13-in. long.

Buckets are fixed to the belt by oval or cup-head bolts, with two fangs or prongs, which grip the belt to prevent rotation, and the heads are very thin, to allow them to be pulled flush into the back of the belt.

When an elevator is working under full load, the buckets are usually full, but to ensure a margin for emergencies—such as intermittent loading—calculations are usually based on the buckets being two-thirds to three-quarters full, so that on this basis an elevator of a nominal capacity of 100 t.p.h. would deal with about 130 t.p.h. when fully loaded.

The elevator casing or "legs" enclosing the belt and buckets consists of two steel casings, made up of flanged steel plate about 14-G thick, with horizontal joint flanges about 8-ft. pitch, and fitted with inspection doors at convenient points, the width of the casing being from 2-in. to 3-in. wider than the belt.

The boot of an elevator confines the material to the path of the buckets; it supports the bottom shaft and pulley, and usually it supports the elevator casing. The tightening gear, for taking up the stretch in the belt, is usually embodied in the boot, the shaft being supported in bearings fixed in slide blocks, actuated by screws, and to counteract any unequal adjustment of the screws, the bearings are of the self-aligning type. The boot is made up of cast iron or steel plates, the latter being about $\frac{3}{16}$-in. thick, and it is a good practice to fit a small door for inspection and cleaning-out purposes.

The purpose of the boot pulley is to keep the belt reasonably taut and in position, and as it can be much smaller than the head pulley, it is usual, in the case of long elevators, to taper the last two or three sections of the elevator casing towards the boot on the return side, and fit a small snub or press pulley in the casing at the bend, whilst for short elevators the return leg is inclined from head to boot.

The elevator head is the delivery point of the material, where the head pulley is fixed for driving the elevator belt. The

Handling and Storage of Grain—continued

Travelling Plant at New Ocean Dock, Southampton, with range of 650-ft. along the quay

diameter of the head pulley, speed of belt, and shape of buckets have to be considered in relation to each other, to obtain an efficient discharge.

Material passing round a circular path is subjected to two forces, one, gravity acting vertically downwards equal to its own weight (W), the other, centrifugal force acting radially outwards with a force equal to $\frac{W\,V^2}{g\,R}$, where V = velocity of mass in feet per second, g = acceleration of gravity (i.e., 32.2-ft. per second), and R is radius in feet to centre of rotation. By setting these two forces down to scale, and completing the parallelogram of forces, we obtain the magnitude and direction of the resultant force. To obtain a clean discharge, the two forces should be equal in amount at a point near the top of the pulley, when the material will be in a state of suspension ready to move forward when the resultant of the two forces on the descending side urge the material towards the mouth of the bucket. That condition of suspension or equilibrium exists when:—$W = \frac{W\,V^2}{g\,R}$, or $V^2 = g\,R$ and since $V = \frac{2\pi R N}{60}$ where N = R.P.M., then $N = 54.19 \frac{1}{\sqrt{R}}$ so that we have a definite relationship between the radius or diameter of the head pulley, and its revolutions per minute.

The theoretical H.P. required to drive an elevator can be derived from first principles. Thus we know 1 H.P. equals 33,000-ft. lbs. of work done per minute. As the belt and buckets on each side are balanced, the work done in an elevator is tons × vertical lift in feet, and to bring this to ft. lbs. of work per minute:—

$$= \frac{T \times 2240 \times H}{60} \text{ and to H.P. } = \frac{T \times 2240 \times H}{33{,}000 \times 60} = \frac{T \times H}{884}$$

and for actual H.P. of motor, add 30 to 50% for inside elevators, to allow for dredging in boot, loss of efficiency in driving gear, etc.

Having found the H.P., we divide this by the speed of the belt, which gives the force required to turn the head pulley, and by adding to this the total weight of the belt and buckets on one side, we obtain the maximum tension in the belt; by dividing the maximum tension by the belt width, multiplied by the safe stress per inch per ply, we obtain the required ply of belt. It is a good practice to have the diameter of the head pulley in inches at least four times the number of piles in the belt, and if possible, five times.

Elevators are driven at the head either by spur or worm reduction gears, or belt.

(To be continued).

Corrigenda.—The following corrections are necessary in the text of the article on "The Principles of Drag-Suction Dredging," which appeared in the August issue of this Journal:—

P. 301, footnote 2, formula should be $\frac{s_2 - 1}{s_1 - 1}$

P. 302, illustration: interchange captions of two upper photographs.

Port of Portland, Oregon, U.S.A.

Excerpts from the Annual Report of the Chairman of the Commission of Public Docks for the Fiscal Year ended 30th November, 1938

The reconstruction of Terminal No. 1, which was completed early in 1938, was carried on in co-operation with the Federal Administration of Public Works. Up to November 30th, 1938, there had been spent for the acquisition of real estate and in reconstruction $882,748.33, of which $383,735.32 was a Federal Grant. The Commission's share of this project was $499,013.01, and was drawn from reserves built up from operating revenues.

In 1938 gross operating revenues were $290,703.87, as against $326,357.38 for the previous year. This decline was largely due to depressed business conditions reflected principally in reduced inter-coastal traffic at Terminal No. 1 and small wheat tonnage moving through Terminal No. 4.

Shipping

Just as gross operating revenues declined in 1938, so did the Commission's tonnage, which totalled 637,373 tons, or 140,023 tons of cargo less than was moved over the public terminals in 1937. The total port deep-sea tonnage of 4,834,061 tons likewise showed a decline of 282,437 tons over the preceding year.

Bonneville Dam

Though the dam was officially dedicated in September, 1937, the sea-locks remained closed to navigation until January 6th, 1938, when the tug "Warco," with a tow of two barges, passed through the locks.

On July 9th, the "Charles L. Wheeler, Jr." of the McCormick Steamship Co., passed through the locks at Bonneville en route from San Francisco to The Dalles—the first sea-going vessel to ascend the Columbia River beyond Vancouver, Wash.

The Report is signed by Mr. John H. Burgard, Chairman.

Studies in Reinforced Concrete

The eighth of the studies in reinforced concrete carried out at the Building Research Station of the Department of Scientific and Industrial Research deals with the strength and deformation of some reinforced concrete slabs subjected to concentrated loading, and is issued by the Department as Building Research Technical Paper No. 25 (published H.M. Stationery Office, 1s.. 3d. net).

The design of reinforced concrete slabs has in the past been based on analysis of plate action according to the theory of elasticity or on rule-of-thumb methods expected to give similar or more conservative results. The theory is based on the assumptions *inter alia* that the plate is homogeneous and wholly elastic, neither of which conditions can be expected to apply to a reinforced concrete slab after the incidence of cracking. The theory of plate action has been solved mathematically for only a limited number of types of loading and restraint, and in some cases the solutions are based on approximate methods which may not be wholly satisfactory. A particular case of difficulty is the analysis of the stresses in a slab in the immediate neighbourheed of a highly-concentrated load. For this case, the ordinary theory of thin plates breaks down and more elaborate analysis is necessary.

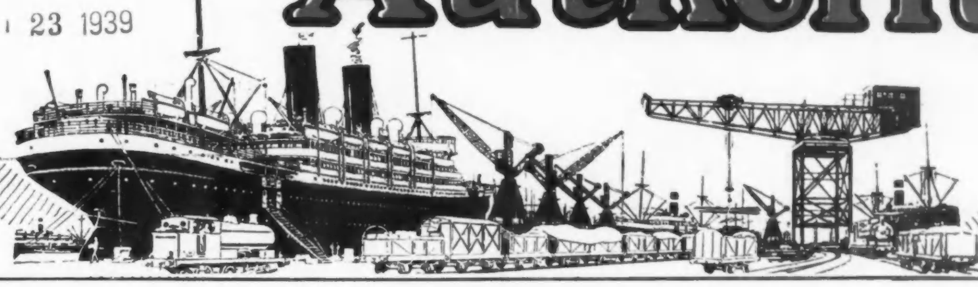
The report now published gives the results of an investigation carried out at the Building Research Station on behalf of the Ministry of Transport, with the object of checking the validity of applying the results of the elastic theory of thin plates to the design of reinforced concrete slabs fixed along two or four edges when loaded over a small area at the centre of the slab.

Publications Received

A convenient and attractive handbook on the Port of Madras has been issued by the Chairman and Trustees of the Port. It is a brochure of 25 pages, with a summarised historical account of the growth and development of the chief harbour on the Coromandel Coast of India, together with particulars of its situation and weather conditions. The latter portion of the brochure is made up of trade statistics and information on charges and management. In the pocket there is a useful plan of the harbour, while the booklet incorporates a number of interesting photographic views.

A copy of a 16 pp. brochure, List 83-IE, has been received from Messrs. John M. Henderson & Co., Aberdeen. It has been compiled with a view to bringing to the notice of public works contractors, dock and harbour engineers, mining companies, etc., the advantages which can be obtained by the use of aerial cableways when dealing with the problem of raising, transporting and depositing or tipping materials in bulk over a wide working area. A number of illustrations show the scope and variety of the different types of cableway described.

The Dock & Harbour Authority



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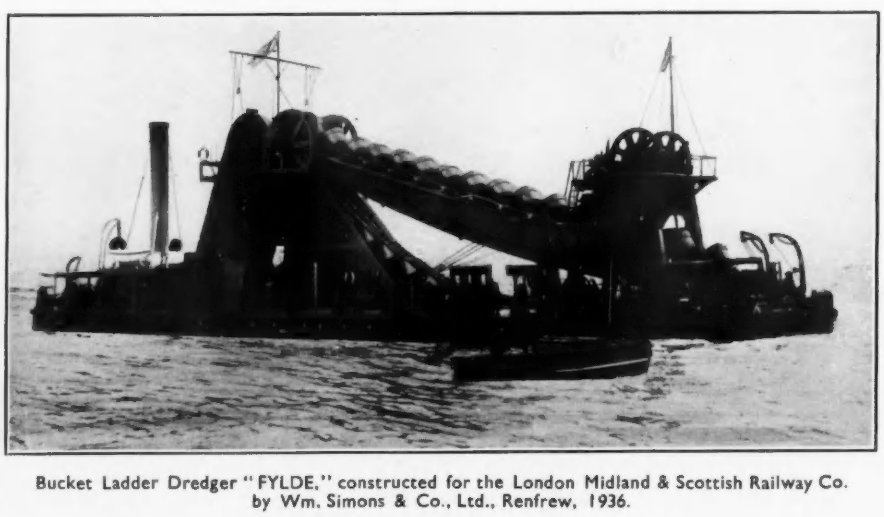

Bucket Ladder Dredger "FYLDE," constructed for the London Midland & Scottish Railway Co. by Wm. Simons & Co., Ltd., Renfrew, 1936.

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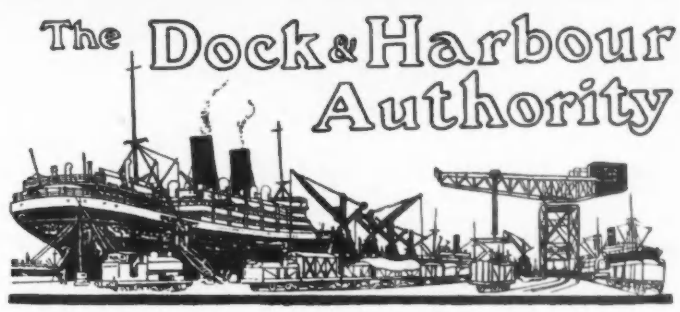

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